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DRAFT FINAL

PHASE I RFI/RI REPORT
WALNUT CREEK PRIORITY DRAINAGE
OPERABLE UNIT NO 6

VOLUME 1

SECTIONS 1 0 THROUGH 3 0
TEXT, TABLES, AND FIGURES

U S Department of Energy
Rocky Flats Environmental Technology Site
Golden, Colorado

September 1995

OU06-428

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TABLE OF CONTENTS

Section			Page

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIXES

OU6 LIST OF ACRONYMS AND ABBREVIATIONS

1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1 1 1-TCA	1,1,1-trichloroethane
1,2-DCA	1,2-dichlorothane
1,2-DCE	1,2-dichloroethene
ac-ft	acre-feet
AEC	Atomic Energy Commission
af	man-made deposits
AGS	above ground surface
Am-241	Americium-241
AMSL	above mean sea level
AOC	Area of Concern
ARARs	applicable or relevant and appropriate requirements
BGS	below ground surface
BSL	Background Screening Level
Ca^{+2}	calcium
$CaCO_3$	calcium carbonate
CCl_4	Carbon tetrachloride
CDPHE	Colorado Department of Public Health and Environment
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment & Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CHC	chlorinated hydrocarbons
$CHCl_3$	chloroform
Cis-1 2-DCE	cis-1 2-dichloroethene
CLC	common laboratory contaminants

cm/sec	centimeters per second
cm	centimeter
COCs	chemicals of concern
CRQL	contract required quantitation limit
C_s-137	Cesium-137
CSM	conceptual site model
DCN	document change notice
d/m/l	disintegrations per minute per liter
DLG	Digital Line Graph
DOE	Department of Energy
DQO	Data Quality Objective
DRCOG	Denver Regional Council of Governments
ECD	Electron Capture Detector
EM	Electromagnetic
EMD	Environmental Management Department
EMRGs	Environmental Management Radiological Guidelines
EPA	Environmental Protection Agency
ER	Environmental Restoration
ERDA	Energy Research and Development Administration
ERP	Environmental Restoration Program
FDM	Fugitive Dust Model
FIDLER	field instrument for the detection of low-energy radiation
FSP	field sampling plan
GAC	granular activated carbon
gal	gallon
GS	gauging station
HCO^3	bicarbonate
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment

HPGe	high purity germanium
HRR	Historical Release Report
HSP	Health and Safety Plan
ID	inside diameter
IHSS	Individual Hazardous Substance Site
in/hr	inches per hour
IRIS	Integrated Risk Information System
K, (K^+)	hydraulic conductivity, (symbol for potassium)
Ka	Cretaceous Arapahoe Formation
Kl	Cretaceous Laramie Formation
LHSU	lower hydrostratigraphic unit
mCi	millicurie
meq/l	milliequivalents
Mgal	millions of gallons
ml	milliliter
mm	millimeters
MSL	mean sea level
Na+	sodium
NAAQS	National Ambient Air Quality Standards
NPDES	National Pollutant Discharge Elimination System
OU	operable unit
OVM	organic vapor monitor
PA	protected area
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PCOC	potential chemical of concern
pCi/g	picocuries per gram
PID	photoionization detector

Pu-239/240	plutonium-239/240
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPjP	Quality Assurance Project Plan
Qc	Quaternary colluvium
QC	quality control
Q_{ls}	Quarternary landslides
Qrf	Quaternary Rocky Flats Alluvium
Qt	Quaternary Terrace Alluvium
Qvf	Quaternary Valley-Fill Alluvium
Ra-226	radium-226
RAD screen	radiological screen
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RFA	Rocky Flats Alluvium
RfCs	reference air concentrations
RfDs	noncarcinogenic reference doses
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
RI	remedial investigation
SEAM	Superfund Exposure Assessment Manual
SFs	carcinogenic slope factors
SO_4^{2}	sulfate
SOP	Standard Operating Procedure
sq ft	square feet
sq mi	square mile

Sr-89 90	strontium-89,90
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TAL	target analyte list
TCE	trichloroethene
TCL	Target Compound List
TM	Technical Memorandum
TOC	total organic carbon
µg/kg	micrograms per kilogram
µg/l	microgram per liter
U-233/234	uranium-233/234
U-235	uranium-235
U-238	uranium-238
UHSU	upper hydrostratigraphic unit
USACE	U S Army Corps of Engineers
USCS	Unified Soil Classification System
UTL	upper tolerance limit
VOC	volatile organic compound
WARP	Well Abandonment and Replacement Program
W&I	Walnut and Indiana

1 0
INTRODUCTION

The Environmental Restoration (ER) Program for the Rocky Flats Environmental Technology Site (RFETS) historically referred to as the Rocky Flats Plant (RFP), is designed to investigate and remediate contaminated sites at RFETS and involves the following five major activities

Activity 1	Installation Assessments
Activity 2	Remedial Investigations
Activity 3	Feasibility Studies
Activity 4	Remedial Designs/Remedial Actions
Activity 5	Compliance

This document presents the results of the Phase I, Resource Conservation and Recovery Act (RCRA) Facility Investigation/Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigation (RFI/RI) of the Walnut Creek Priority Drainage also known as Operable Unit No 6 (OU6), at RFETS Jefferson County, Colorado This Phase I investigation is a component of Activity 2 of the ER Program

The Phase I RFI/RI Work Plan for OU6 was submitted to the U S Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE), formerly the Colorado Department of Health (CDH), in 1992 The field sampling plan (FSP) specified in the OU6 Phase I Work Plan (DOE 1992a), hereafter known as the Work Plan, was designed to assess the nature and extent of contamination in 21 Individual Hazardous Substance Sites (IHSSs) along or within the North Walnut Creek and South Walnut Creek drainages The Phase I field investigation was conducted during 1992 and 1993

This report summarizes the field activities performed during the Phase I investigation, characterizes the environmental setting characterizes contaminant sources and the nature and extent of contamination in soils groundwater surface water sediments, air and biota discusses contaminant fate and transport and includes a Baseline Risk Assessment (BRA)

The results presented in this document are based on existing information that was used to initially characterize OU6 (1986-1989 boreholes) and on data acquired during the Phase I investigation Results of the Phase I investigation have been used to

- Estimate risks to human health and the environment posed by OU6 IHSSs,

- Identify any further need for evaluation of the OU6 IHSSs

Section 1 0 of this document provides an introduction, an organization of the Phase I RFI/RI report, investigation objectives, a brief discussion of the background of RFETS, OU6 IHSS locations and descriptions, a summary of previous and ongoing investigations, and a summary of the Work Plan and technical memoranda.

1 1 REPORT ORGANIZATION

The OU6 Phase I RFI/RI Report is organized into ten major sections, including references and appendixes as shown below

- Section 1 0, Introduction, describes the report organization, presents the purpose of the project, presents background information, and provides summaries of the Phase I Work Plan and technical memoranda.

- Section 2.0, OU6 Field Investigation, presents the scope of the Phase I field investigation, describes the field activities, sampling procedures and analytical methods, and documents deviations from the work plan

- Section 3 0, Physical Characteristics of OU6, describes the physiographic features, demography and land use, meteorology and climatology, soils geology, hydrogeology, surface water, ecology, and the physical characteristics of each IHSS in OU6

- Section 4 0 Nature and Extent of Contamination, describes the nature and extent of contamination in surface soils, subsurface soils, groundwater, surface water, sediments, and air This section begins with a description of the analytical data used, how data are compared to background data, and how detected compounds are evaluated A detailed description of the nature and extent of contamination in each medium is presented for each IHSS and specific non-IHSS areas

- Section 5 0 Contaminant Fate and Transport discusses the factors that affect the movement and persistence of the contaminants identified in Section 4 0 This section also includes a summary of the fate and transport modeling performed to support the risk assessment.

- Section 6 0 Baseline Human Health Risk Assessment presents a summary of the baseline HHRA for OU6 (the complete baseline HHRA is presented in Appendix J)

- Section 7 0 Environmental Evaluation (hereafter referred to as Ecological Risk Assessment [ERA]), presents a summary of the evaluation of the nature and extent of contamination in biota, its relationship to abiotic sources, and the extent and type of adverse effects on the ecosystem community, population and individual levels of biological organizations (the complete Ecological Risk Assessment is presented in Appendix F)

- Section 8 0 Conclusions and Recommendations presents a summary of the findings of the report and includes remediation recommendations

- Section 9 0 contains the References cited in the report

- Appendixes

  - Appendixes B and C provide field survey data and geologic/hydrogeologic data, respectively

  - Appendix D provides the OU6 Phase I analytical data

- Appendix E provides details of the quality assurance/quality control procedures implemented for this project.

- Appendix F presents the Ecological Risk Assessment

- Appendix G provides the detailed methodology, assumptions, and results of the groundwater modeling conducted for OU6

- Appendix H provides the detailed methodology, assumptions and results of the surface water modeling conducted for OU6

- Appendix I provides the detailed methodology, assumptions, and results of the air modeling conducted for OU6

- Appendix J contains the OU6 Phase I Baseline Health Risk Assessment

1 2 INVESTIGATION OBJECTIVES

The objectives of the Phase I RFI/RI at OU6, as defined in the Work Plan (DOE 1992a), are:

- To characterize the physical and hydrogeologic setting of the IHSSs
- To assess the presence or absence of contamination at each IHSS
- To characterize the nature and extent of contamination at each IHSS, if present
- To support the Phase I Baseline Risk Assessment

Within these broad objectives, site-specific data quality objectives were developed and identified in Section 4.0 of the OU6 Work Plan and are presented in Section 1 4 1 of this report

1 3 BACKGROUND

The following sections describe in general the plant operations at Rocky Flats, summarize the historical activities at each IHSS in OU6 and discuss previous and ongoing plant-wide and OU6-specific investigations

1 3 1 Plant Operations

RFETS, located northwest of Denver CO (Figure 1 3-1), is a government-owned, contractor operated facility consisting of approximately 6,550 acres of federal land It is part of the nationwide nuclear weapons production complex Major plant buildings are located within a Plant security area of approximately 400 acres The security area is surrounded by a buffer zone of approximately 6 150 acres (Figure 1 3-2)

Historically RFP was operated for the U S Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975 At that time, responsibility for RFP was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the Department of Energy (DOE) in 1977 Dow Chemical U S A an operating unit of the Dow Chemical Company, was the prime operating contractor of the facility from 1951 until June 30, 1975 Rockwell International was the prime contractor responsible for operating the RFP from July 1, 1975 until December 31 1989 EG&G, Rocky Flats Inc was the prime contractor at the RFP from January 1, 1990 until June 30 1995 On July 1, 1995 management of the RFETS was transferred to Kaiser-Hill Inc

The primary mission of the RFP was to fabricate nuclear weapon components from plutonium uranium and non-radioactive metals (principally beryllium and stainless steel) Parts made at RFP were shipped elsewhere for assembly In addition RFP reprocessed components for recovery of plutonium after removal from obsolete weapons

Both radioactive and non-radioactive wastes were generated in the production process Current waste handling practices involve onsite and offsite recycling of hazardous materials onsite storage of hazardous and radioactive mixed wastes, and offsite disposal of solid radioactive materials at another DOE facility However, both storage and disposal of hazardous and radioactive mixed wastes occurred onsite in the past Preliminary assessments under the ER Program identified some of the past, onsite storage and disposal locations as potential sources of environmental contamination

1.3 2 OU6 IHSS Locations and Descriptions

OU6 consists of 19 IHSSs located within or adjacent to the Walnut Creek drainages These IHSSs consist of the Sludge Dispersal Area (IHSS 141), the four A-Series Ponds along North Walnut Creek (IHSSs 142 1 through 142 4), the five B-Series Ponds along South Walnut Creek (IHSSs 142 5 through 142 9), the Walnut and Indiana (W&I) Pond along Walnut Creek (IHSS 142 12), the Old Outfall Area (IHSS 143), the Soil Dump Area (IHSS 156 2), the Triangle Area (IHSS 165), Trenches A, B, and C (IHSSs 166 1, 166 2, and 166 3, respectively) the North Spray Field Area (IHSS 167 1), and the East Spray Field Area (IHSS 216 1) (Figure 1 3-3) The Pond Spray Field Area (IHSS 167 2), and the South Spray Field Area (IHSS 167 3), previously included in the OU6 Phase I investigation, have been included in OU7 for characterization and evaluation However, IHSS 167 3, as presented in the work plan, was retained in OU6 based on historical knowledge Figure 1 3-3 also shows the historical and revised boundaries for IHSS 167 2

Each IHSS was assigned an IHSS reference number by Rockwell International (DOE 1987) The IHSS boundaries were revised in the Historical Release Report (HRR) (DOE 1992b) based on reevaluation of aerial photographs and other historical records of waste disposal practices in OU6 The HRR revisions changed the locations of IHSSs 167 2 and 167 3, and adjusted the boundaries of five additional IHSSs, as shown on Figure 1 3-3 (pages 1 and 2) Because the OU6 Work Plan was completed prior to revision of the IHSS boundaries in the HRR, field sampling activities were completed according to the specifications of the Work Plan based on previous IHSS boundaries The Phase I boreholes and wells, however, were located in the field after a review of the historical data and aerial photographs Therefore some sampled areas are not congruous with the IHSS areas presented in the HRR, and sampled areas may not characterize a specific revised IHSS The revised IHSS locations found in the HRR are used in Sections 2 0 through 9 0 of this report

The following site descriptions are taken from the OU6 Work Plan (DOE 1992a), which was based on descriptions in the RFP Comprehensive Environmental Assessment and Response Program (CEARP) Phase I Report (DOE 1986a), the RCRA Part B-Operating Permit

Application (DOE 1987), and from the HRR (DOE 1992b) The descriptions in these documents were based on historical records, aerial photography review and interviews with RFETS personnel

1 3 2 1 Sludge Dispersal Area (IHSS 141)

The Sludge Dispersal Area (IHSS 141) is located along the eastern perimeter of the security area of RFETS The western half of IHSS 141 is located within the security area of RFETS (Figure 1 3-4) Two corrugated metal buildings (Building 974 and Drying Beds 5, 6 and 7), located in the western half of IHSS 141 cover the present day drying beds of the Sewage Treatment Plant (STP) The eastern half of IHSS 141 slopes eastward toward South Walnut Creek and the B-Series Ponds Two paved roads cross this IHSS in a north-south direction One of the roads is within the security area while the other is located in the buffer zone A drainage ditch separates these two roads, with the ditch being located on the outside of the security fence The water which collects in this drainage ditch flows into the B-Series Ponds

Prior to 1983 the Sludge Dispersal Area received airborne particles (radioactive) from dried sludge packaging operations (Rockwell 1988a) The sludge was generated by the sewage treatment facility located in the western portion of this IHSS In addition, this area may have received spillage of dried or drying sludge from drying beds located west of IHSS 141

Radioactive laundry effluent was the only known radioactive effluent entering the drying beds between 1969 and 1972 By the latter half of 1972, however plumbing changes were made and all Plant wastes were channeled through the STP and then into the drying beds This resulted in increased radioactivity levels in the sludges (Owen and Steward 1973) In June 1972 an overflow incident occurred in June 1972 from Building 701 This incident resulted in elevated levels of plutonium entering the STP, and subsequently the drying beds (Owen and Steward 1973)

1 3 2 2 North Walnut Creek and South Walnut Creek

The RFETS security area is located on a plateau which is bounded on the north by North Walnut Creek North Walnut Creek and South Walnut Creek are intermittent streams that receive surface runoff from the northern and eastern portion of the RFETS facility and adjoining buffer zone An unnamed tributary (located one half mile north of the facility and north of North Walnut Creek) receives surface runoff collected from the northern buffer zone All three of these creeks merge into Walnut Creek within the buffer zone about one mile northeast of the security area (Figure 1 3-2) Walnut Creek flows toward Great Western Reservoir located approximately one-third mile east of the eastern boundary (Indiana Street) of the RFETS The water from Walnut Creek is diverted around Great Western Reservoir by the Broomfield Diversion Ditch and is carried to Big Dry Creek

The headwaters of North Walnut Creek originate within the Upper Church Ditch, approximately 1 5 miles west of RFETS This ditch divides within the western buffer zone forming McKay Ditch and Church Ditch (Figure 1 3-2). The McKay Ditch further divides, forming the North Walnut Creek drainage, which continues for approximately 3 miles before converging with South Walnut Creek to form Walnut Creek

South Walnut Creek originates near the center of the RFETS security area and bisects the eastern half of the security area (Figure 1 3-2) South Walnut Creek converges with North Walnut Creek approximately one mile east of the eastern boundary of the RFETS security area The original headwater area of South Walnut Creek was backfilled during construction of the RFETS facilities, therefore flow begins near a buried culvert west of Building 991 (Figure 1 3-4)

The natural drainage of North Walnut Creek and South Walnut Creek have been modified in OU6 by the construction of detection ponds These detention ponds (the A and B-Series Ponds) serve to temporarily detain surface water runoff from the RFETS facilities and buffer zone for the purpose of sampling and performing analyses prior to release downstream These detention ponds are also used for spill control management Sections 1 3 2 3 and 1 3 2 4 provide detailed descriptions of these ponds

1.3 2.3 A-Series Ponds (IHSSs 142 1 through 142.4)

Ponds A-1 A-2 A-3 and A-4 (IHSSs 142 1 through 142 4, respectively) are located in North Walnut Creek, northeast of the RFETS security area (Figure 1 3-3) These ponds were generally constructed by the placement of earthen embankments or dams across North Walnut Creek (Figure 1 3-5) The estimated storage at 100 percent capacity for Ponds A-1 through

A-4 are 1 400 000 gallons (gal), 6,000,000 gal, 12,370 000 gal and 32,490,000 gal, respectively (Merrick 1992) The size of these ponds vary seasonally but are usually maintained at 10 percent capacity

The A-Series Ponds are used primarily to capture and control surface water runoff from the northern part of the RFETS production facilities and from North Walnut Creek Historically, the A-Series Ponds received discharges from several different sources Between 1952 and 1979 Pond A-1 was used to hold water that was discharged into North Walnut Creek from the northern production facilities, including Building 771 outfall, which contained nitrates and radioactive substances such as plutonium and uranium (DOE 1992b) Pond A-1 also received process liquid waste cooling tower blowdown and steam condensate discharges which contained chromates and algicides After the construction and completion of Pond A-2 (1974) and prior to 1978 the water from Pond A-1 was allowed to flow into Pond A-2 where the water was disposed of by natural and spray evaporation (Hurley 1979)

The above mentioned discharges although long since discontinued produced measurable amounts of plutonium in the stream sediments of North Walnut Creek and in the sediments of Pond A-1 (DOE 1980) Pond A-1 is presently used for spill control management and receives only local surface water runoff and groundwater seepage that may occur in the area The water collected in this pond is currently disposed of by natural and spray evaporation Pond A-2 received process wastewater and laundry wastewater from Ponds A-1 and B-2 (IHSS 142 6) The water from Pond B-2 is pumped to Pond A-2 via pipeline (Figure 1 3-3, page 1 of 2) The water from Pond A-2 has always been disposed of by natural and spray evaporation Pond A-2 is presently used for spill control management and receives only local surface water runoff and groundwater seepage that may occur in this area

Pond A-3, constructed in 1974 continues to be used to impound surface water runoff from the northern plant facilities and North Walnut Creek Waters originating upstream in North Walnut Creek are diverted around Ponds A-1 and A-2 by the A-2 bypass culvert (Figure 1 3-5) and channeled into Pond A-3 The water is temporarily detained in Pond A-3 before being released into Pond A-4

Pond A-4, constructed in 1979, historically received water from Pond A-3 Presently, Pond A-4 receives water from Ponds A-3 and B-5 (the water from Pond B-5 is pumped into Pond A-4)

1.3.2 4 B-Series Ponds (IHSSs 142.5 through 142.9)

Ponds B-1 B-2, B-3, B-4, and B-5 (IHSSs 142 5 through 142 9, respectively) are located in South Walnut Creek, east of the eastern perimeter of the RFETS security area (Figure 1 3-3, Page 1 of 2) The estimated storage at 100 percent capacity for Ponds B-1 through B-5 are 1,140,000 gal, 1,500,000 gal, 570,000 gal, 180,000 gal, and 24,650,000 gal, respectively (Merrick 1992) The relative pond sizes are shown in Figure 1 3-6

The B-Series Ponds were generally constructed by the placement of earthen dams across South Walnut Creek Outlet structures and spillways were constructed on some of the dams to regulate flow out of these detention ponds and to channel excess water around the embankments when the ponds are near full capacity

The B-Series Ponds are used primarily to capture and control surface water runoff from the eastern and central portions of the RFETS production facilities The major component of RFETS discharges to the B-Series Ponds to date is the sanitary effluent from the sanitary wastewater treatment plant (Building 995) (DOE 1992b) Historically, several other waste disposal activities have been associated with the B-Series Ponds since the beginning of plant operations in 1952 Between 1952 and 1973, decontaminated process water and laundry wastewater were released into South Walnut Creek and subsequently into Ponds B-1 through B-4 Nitrate, plutonium, and uranium were contained in these wastes, the volume of wastes released into South Walnut Creek is unknown (Rockwell 1988a)

Pond reconstruction activities between 1971 and 1973 resulted in disturbances of the bottom sediment of the channel upstream of Pond B-1 This construction caused much of the upstream sediment to be transferred to Pond B-1, increasing the total plutonium levels (DOE 1980) As a result of this activity, there are probably several additional curies of plutonium presently trapped in the sediment within the waste discharge pipe and the inlet of Pond B-1 (Rockwell 1988a)

Presently Ponds B-1 and B-2 are used for spill control management and to detain local surface water runoff and seepage that may occur from nearby areas Pond B-3 receives effluent from the STP and local surface water runoff Pond B-4 receives discharges from Pond B-3 The water in Pond B-4 is released into Pond B-5

Pond B-5 constructed in 1979 was used as an overflow pond for Pond B-4 In 1991, a diversion pipeline structure was built from Pond C-2 to Pond B-5 Presently, Pond B-5 receives water from Pond B-4 and surface water runoff from the Central Avenue Ditch (Figure 1 3-6)

1 3 2 5 <u>Walnut and Indiana (W&I) Pond (IHSS 142.12)</u>

The W&I Pond (IHSS 142 12) is located along Walnut Creek approximately 2,500 feet east of the confluence of North Walnut Creek and South Walnut Creek and immediately west of Indiana Street (Figure 1 3-3, page 2 of 2) The W&I Pond was constructed to collect flow measurements on Walnut Creek This is accomplished using two Parshall Flumes (6-inch throat and 36-inch throat) Sediments transported by North Walnut Creek and South Walnut Creek may settle in IHSS 142 12 due to the quiescent conditions of this pond The effluent from this pond is sampled on a daily basis when discharging Discharging occurs when the capacity of the pond is exceeded by the influent Water discharged from the W&I Pond flows downstream into Walnut Creek

1 3 2 6 <u>Old Outfall Area (IHSS 143)</u>

The Old Outfall Area (IHSS 143) is located to the northwest of Building 773 (Guard Station) and Building 771 within the protected area (PA) (Figure 1 3-3 page 1 of 2) A detailed map of IHSS 143 is shown on Figure 1 3-7 The Old Outfall Area is approximately 30 000 square feet in area and has been covered with fill (amount of fill and date unknown) Temporary trailers and the PA fence are currently situated on or near this IHSS Because of the PA fence construction, the present day drainage system is different from the drainage system that existed during the operation of the Old Outfall

The Old Outfall Area acted as a catchment basin that received liquids from various sources, the main source being the laundry holding tanks in Building 771 (Dow 1971a) If plutonium concentrations were found to be below 3,300 disintegrations per minute per liter (d/m/l), liquid waste containing plutonium was discharged from these holding tanks into the Old Outfall Area. Between mid-1953 through mid-1957, 4 5 million gal, of liquid were released into the Old Outfall area. Approximately 2 23 millicuries (mCi) of plutonium were released with these liquids (Dow 1971a) At no time did concentrations from the discharge exceed 1 000 d/m/l In 1957, a waste line was installed to allow liquid from these holding tanks to flow to Building 774 However, due to occasional equipment problems, periodic releases from these holding tanks occurred between 1957 and 1965 into the Old Outfall Area and subsequently into North Walnut Creek During this period, 434,000 gal of liquid containing 0 25 mCi of plutonium were released to the Old Outfall Area (Dow 1971a)

Other sources of discharge to the Old Outfall Area from Building 771 included the analytical laboratory and radiography sinks, the personnel decontamination room (showers), and runoff from the roof and adjacent ground areas around the building No documentation specific to the quantities of liquid or radioactivity of these liquids was recorded (Dow 1971a)

The plutonium concentrations in these discharges resulted in soil contamination at the point of discharge at the Old Outfall Area (Dow 1973) The first occurrence of soil contamination at the Old Outfall was reported in May 1956, and soil contamination was reported again in May 1958 (Dow 1971a) It is not known if these contaminated soils were removed from this area

In May 1968, a sewer line broke at Building 771, causing the sewage lift station tank (located west of Building 771, Figure 1.3-8) to overflow into the Old Outfall Area. Low concentrations of radioactive materials (including plutonium) and various chemicals were detected in the soils near the Old Outfall Area following this spill (Rockwell 1988a) In April 1970, elevated radioactivity readings were detected in the soils at the Old Outfall Area and soil samples were collected and analyzed In June 1970, the area between Building 771, the Old Outfall Area and North Walnut Creek was radiologically surveyed, and in September, contaminated soils were removed from an area of approximately 75 square feet (sq ft) (Dow 1971b) The location of the excavation was not specified

In early 1971, an alpha survey and soil sampling at the Old Outfall Area revealed that an area of approximately 800 sq ft was contaminated with plutonium One small area indicated contamination to a depth of 3 5 feet (Dow 1971c) Removal of soils from an 800 sq ft area at the Old Outfall Area began in February 1971 and was completed in early August 1971 (Figure 1 3-8) Soil was initially removed from an area 2 5 feet deep, 3 feet wide and 15 feet in length The depth of this excavation decreased to a depth of about 1 foot in the area farthest from the discharge point East of this excavation, a second area, approximately 25 feet by 30 feet, was excavated to a depth of approximately 1 foot (Dow 1971a) Excavation activities were performed only when the soils were relatively dry to reduce the potential for liquid to collect in the waste drums Cement was added to each drum before and after the placement of the soil into the drums to absorb any liquid that may have been contained within the soil The excavated area and the soil sample results from this area are presented in Figure 1 3-8 Following these soil removal activities, the area was considered to be free of significant plutonium concentrations (Dow 1971c)

1 3 2 7 Soil Dump Area (IHSS 156 2)

The Soil Dump Area (IHSS 156 2) is located within the buffer zone northeast of the northeastern boundary of the RFETS security area and northeast of the Triangle Area (Figure 1 3-4) Geographically IHSS 156 2 is located on an east-west trending interfluve that separates North Walnut Creek and South Walnut Creek in the vicinity of the A and B-Series Ponds (Figures 1 3-3 page 1 of 2) A gravel road bisects this IHSS in a northeast, southwest direction The Soil Dump Area covers an area of approximately 255,000 sq ft (5 9 acres)

The Soil Dump Area received between 50 to 75 dump truck loads (actual quantity unknown) of soil containing low levels of plutonium (DOE 1992b) These soils were excavated during the construction of Parking Area No 334 located in the western half of the security area However the excavated soils removed from Parking Area No 334 originally had been excavated near Building 774 located approximately 100 feet east of Building 771 near the Old Outfall Area (Figure 1 3-3 page 1 of 2) Asphalt debris and concrete remains were also found within the Soil Dump Area Based on the questionable origin of these soils the presence or absence of contamination is unknown

1.3 2 8 Triangle Area (IHSS 165)

The Triangle Area (IHSS 165) is located within the RFETS security area, between the Perimeter Road on the north and Spruce Avenue on the south (Figure 1 3-4) The southwestern corner of this IHSS overlaps slightly with IHSS 176 of OU10 The western two-thirds of this IHSS are within the PA The PA fencing crosses through the eastern one-third of this IHSS in a north-south direction The PA fence area consists of two fences approximately 100 feet apart with a concertina wire center The area between the fences is inaccessible (Figure 1 3-4) The Triangle Area is not paved, but has been partially covered with gravel fill and is sparsely vegetated IHSS 165 covers an area of approximately 250,000 sq ft (5 7 acres)

The Triangle Area inside the PA is presently used as a storage yard for various types of equipment However, between 1966 and 1975, the Triangle Area was used as a storage site for miscellaneous wastes During the latter half of 1966, the Triangle Area was first used as a drum storage area when it became necessary to move a large number of drums to the Triangle Area from a field north of Building 883 The drums were placed directly on the ground through the winter of 1966 In the spring of 1967, the Chemical Operations Department at Rocky Flats categorized all drums based on contents and placed them on wooden pallets (Dow 1974a) Various scrap materials stored in the drums included graphite molds crucibles, incinerator ash heels, crucible heels, Raschig Rings and combustible wastes (Dow 1974b) These scrap materials were stored in the drums pending processing for plutonium in Building 771 Drums containing graphite and washables were also stored in the Triangle Area in March 1967 Surfaces of surplus equipment stored in the area during this time had detectable concentrations of alpha contamination This contamination apparently had blown into the area from the nitrate ponds or solar evaporation ponds located to the west of the Triangle Area (Dow 1974a) By December 1968, approximately 5,000 drums had been placed in the Triangle Area High winds during December 1968 damaged many of the drums located in the Triangle Area. A fire occurred in Building 776 in May 1969 Following cleanup operations, the accumulated fire waste and residues were drummed and the drums were placed in the Triangle Area for temporary storage (Dow 1974a)

On five separate occasions one in 1969, one in 1971, and three times in 1973, leaking drums were discovered at the Triangle Area. In January 1969, approximately 29 drums were found leaking in the Triangle Area This leakage affected an area of about 200 sq ft (Owen and Steward 1973) The soil was removed and shipped as contaminated waste to an offsite facility Following this 1969 spill all the drums in the Triangle Area were placed in rail/truck cargo containers to help minimize future leakage This transfer was completed by 1971 (Dow 1974a)

The type of drums and liners used for the storage of wastes in the Triangle Area varied The 55 gallon drums used for containment of wastes through 1969, were made of an inexpensive material with liners made of double polyethylene bags that had previously been used to contain miscellaneous wastes During 1969, the Chemical Operations group began cutting lids from peroxide container liners, and using these liners as inside liners for the drums By 1971 the use of used drums was discontinued due to several spills and leaks which had resulted from drum deterioration and higher quality drums were purchased for use (Dow 1974a)

In spite of the efforts to contain all wastes in higher quality drums and cargo containers, leaking drums were once again discovered in the Triangle Area The contaminated soil resulting from this incident was removed from an area of approximately 1,000 sq ft Wastes contained in the leaking drums within the cargo containers apparently included incinerator ash heels and Fulflo filters (Owen and Steward 1973) Insufficient drying of the incinerator ash heels and Fulflo filters may have contributed to the deterioration of the drums This may have resulted in the accumulation of dilute nitric acid, which eventually penetrated the bottom of the drums Condensation of moisture during periods of cold weather may also have contributed to liquid accumulation within the drums and eventually penetration of the wastes through the bottom of the drums (Dow 1974b) After the 1971 incident, the bottom of cargo containers used for waste storage were routinely fiberglassed on the inside with fiberglass running up approximately one inch on each of the four inner walls This addition was to enhance and improve containment of the waste and any moisture buildup within the cargo containers (Dow 1974a)

From June 1973 to September 1973 200 yards of plutonium contaminated soil was excavated from waste storage tanks near Building 774, and stored in drums on the east side of IHSS 165 (Owen and Steward 1973)

In September and October 1974, an initial radiometric survey of the Triangle Area identified 26 areas above background Several additional radiometric surveys were conducted on portions of the Triangle Area during the first half of 1975, and no additional elevated readings above background were discovered Locations where the surveys were conducted in the Triangle Area are not known

By June 1975, all cargo containers were removed from the Triangle Area and shipped to an approved facility in Idaho The Triangle Area has not been used since for radioactive storage (Rockwell 1988a) Following the removal of the cargo containers, a radiometric soil survey was conducted over an area of approximately 4,000 sq ft in the Triangle Area No elevated readings were identified from the survey However, six drums of soil were excavated from areas previously discovered to contain elevated readings, and were sent to the drum counter at Building 771 (Dow 1975) A second radiometric survey was conducted in the Triangle Area in July 1975 covering an area of approximately 2,000 sq ft Two very small areas with elevated readings were detected, but no soil was removed from these areas at that time (Rockwell 1975a)

In a letter dated July 13 1979 from Rockwell International to DOE (Rockwell 1979a), the results from a radiometric soil survey conducted within the PA and specifically the Triangle Area were presented Four areas within the Triangle Area had above-background readings. By January 1980, the soil in these designated areas had been removed (Rockwell 1980a). The amount of soil removed from these areas is unknown (Figure 1 3-4)

A preliminary review of aerial photographs conducted for the OU6 Work Plan revealed that in addition to the 55 gallon drums stored in IHSS 165, miscellaneous equipment was also present on the west and northwest portion of the IHSS between 1971 and 1983 Stained soils were visible in the northwest corner of this IHSS in a 1971 aerial photograph In a 1986 aerial photograph, a minimal amount of material such as pipe, and scrap metal was present at the Triangle Area (EPA 1988)

1 3 2 9 <u>Trenches A, B and C (IHSSs 166.1, 166.2, and 166.3)</u>

Trenches A B and C (IHSSs 166 1, 166 2 and 166 3, respectively) are located north of the RFETS security area on a plateau that separates North Walnut Creek and the unnamed tributary to the north (Figure 1 3-3, page 1 of 2) Trench A (IHSS 166 1) is estimated to have dimensions of approximately 80 feet by 190 feet and is located about 100 feet southeast of the present landfill (Figure 1 3-9) Trench B (IHSS 166 2) is estimated to be approximately 90 foot wide by 190 foot long and is located approximately 125 feet south of IHSS 166 1 Trench C (IHSS 166 3) consists of two separate trenches The westernmost Trench C is located between IHSS 166 1 and IHSS 166 2 and is approximately 60 feet by 200 feet The easternmost Trench C is located about 250 feet east of IHSS 166 1 and is estimated to be 40 feet by 100 feet in size

The history of these IHSSs and the dates they were active are based primarily on aerial photographs (EPA 1988) Aerial photographs dated October 15, 1965 show areas of soil disturbance at the trenches locations Little documentation is available concerning their operational histories The HRR (DOE 1992b) concluded that information on IHSSs 166 1 through 166 3 is vague and conflicting The exact location and contents of the trenches are not documented, however, sludge and liquid from the wastewater treatment plant may have been buried in the Trenches IHSS 166 1 appeared to be active from 1964 until approximately 1974 (Rockwell 1988a) IHSS 166.2 was active in 1958 though the closure date of this trench is unknown Evidence of IHSS 166 2 was still visible in the 1988 aerial photograph after which time this area began to revegetate IHSS 166 3 was active from 1964 until possibly 1974 (DOE 1986b) In a 1978 photograph, a road had been built across a portion of IHSSs 166 1 and 166 3

IHSSs 166 1 and 166 2 received uranium and/or plutonium contaminated sludge from the STP (Rockwell 1988a) No other materials or wastes are known to have been placed in these trenches Materials placed in IHSS 166 3 are unknown, but it is probable that sewage sludge was also placed within this trench

1 3 2 10 North Spray Field and South Spray Field Areas (IHSSs 167 1 and 167 3)

The North Spray Field and South Spray Field Areas (IHSSs 167 1 and 167 3) are located north of the RFETS security area and north of North Walnut Creek (Figure 1 3-3 page 1 of 2) The North Spray Field Area occupies approximately 172 500 sq ft (3 96 acres) The South Spray Field Area occupies approximately 40 000 sq ft (0 92 acres) These spray fields are presently covered by grasses common to the Rocky Flats area As previously mentioned the Pond Spray Field Area (IHSS 167 2), shown on Figure 1 3-3 (page 1 of 2), will be addressed under the OU7 RFI/RI Report

The periods during which IHSSs 167 1 and 167 3 were operational are not precisely known However, the spray fields were used shortly after the present Landfill (IHSS 114) became active in 1968 (Figure 1 3-9) These spray fields were used solely for the purpose of spraying water over the ground surface to enhance evaporation of the water from the ponds located near the present Landfill (IHSS 114) (Figure 1 3-9) and from Buildings 771 and 774 footing drains The East Landfill Pond is the existing landfill pond (Figure 1 3-9) and is used to intercept groundwater that may have been contaminated by leachate generated at the Landfill and is used for spill control management. The West Landfill Pond, which was covered over in May 1981 had been used to impound leachate generated by the Landfill

Spray evaporation, selected as the method to dispose of water from the landfill ponds, was first applied in the South Spray Field Area (IHSS 167 3) During operation of this spray field surface water runoff was found to be draining toward North Walnut Creek The use of this field was subsequently discontinued and the spray irrigation was moved to the North Spray Field Area (IHSS 167 1) During operation of this spray field, the sprayed water was found to be draining into the Unamed Tributary and, subsequently, into Walnut Creek The spraying was again discontinued and moved to the Pond Spray Field Area (IHSS 167 2)

The water sprayed onto these fields contained varying amounts of low-level radioactivity derived from tritium, strontium, plutonium and americium (DOE 1992b) Low concentrations of phenol and nitrate were also detected in the spray water

1.3 2 11 East Spray Field Area (IHSS 216.1)

The East Spray Field Area (IHSS 216 1) is located northeast of the northeastern boundary of the RFETS security area (Figure 1 3-3, page 1 of 2) It is geographically located on an east-west trending interfluve that separates North Walnut Creek and South Walnut Creek in the vicinity of the A and B-Series Ponds The East Spray Field Area covers an area of approximately 150,000 sq ft (3 4 acres Figure 1 3-6)

This spray field became operational in 1989 to provide an additional area to accommodate the spray evaporation of water from Pond B-3 The water in Pond B-3 is from the effluent of the STP and local surface water runoff The use of this area as a spray field stopped shortly after it became operational in the latter part of 1989 due to excessive runoff problems

1 3 3 Previous Investigations

Various studies have been conducted at RFETS to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment These have included geological studies, surface water and groundwater studies, and geophysical and radiometric surveys Several environmental, ecological and public health studies culminated in the Final Sitewide Environmental Impact Statement (DOE 1980) The historical term, RFP is used in this section due to the historical nature of the investigations Previous site-wide investigations (prior to 1986) have included

- Detailed descriptions of the regional geology (Malde 1955 Spencer 1961 Scott 1960, 1963 1970, 1972, and 1975 Van Horn 1972 and 1976, DOE 1980 Dames and Moore 1981, and Robson et al 1981a and 1981b)

- Several drilling programs, beginning in 1960, that resulted in the construction of approximately 60 monitoring wells by 1982

- An investigation of surface and groundwater flow systems by the U S Geological Survey (Hurr 1976)

- Environmental, ecological and public health studies which culminated in an environmental impact statement (DOE 1980)

- A summary report on groundwater hydrology using data from 1960 to 1985 (Hydro-Search, Inc 1985)

- A preliminary electromagnetic survey of the RFP perimeter (Hydro-Search Inc 1986)

- A soil gas survey of the RFP perimeter and buffer zone (Tracer Research, Inc 1986)

- Routine environmental monitoring programs addressing air, surface water, groundwater, and soils These programs are summarized in the annual environmental monitoring reports (Rockwell 1975b, 1976, 1977, 1978, 1979b, 1980b, 1981 through 1985, and 1986a) Additional information on routine environmental programs is also presented in post-1986 annual environmental monitoring reports (Rockwell 1987a and 1989a, EG&G 1990a)

In 1986, two major environmental investigations were completed at RFP The first was the CEARP Installation Assessment (DOE 1986a), which included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported A number of sites that could potentially have adverse impacts on the environment were identified These sites were designated as Solid Waste Management Units (SWMUs)(DOE 1987) and were divided into three categories

1 Hazardous waste management units that will continue to operate and need a RCRA operating permit

2 Hazardous waste management units that will be closed under RCRA interim status

3 Inactive waste management units that will be investigated and cleaned up under Section 3004(u) of RCRA or under CERCLA

The acronym SWMU was later renamed with IHSS The term IHSS will be used throughout this report

The second major environmental investigation completed at RFP in 1986 involved a hydrogeologic and hydrochemical characterization of the entire RFP site Results of these investigations were reported by Rockwell International (1986b) Investigation results indicated four areas to be significant contributors to environmental contamination, with each area containing several sites The areas are the 881 Hillside Area, the 903 Pad area, the Mound Area, and the East Trenches Area. Due to their proximity, the 903 Pad Mound and East Trenches areas were grouped together and designated OU2 The 881 Hillside was designated as OU1

In 1989 and 1990 two radiological surveys were conducted at RFP The aerial radiological survey in 1989 (DOE 1990a) consisted of airborne measurements of both natural and man-made gamma radiation from the terrain surface in and around RFP In 1990, in situ radiological surveys were conducted at RFP (DOE 1991b)

Four other RFP-wide studies have been conducted that further supplement OU6 RFI/RI activities the geologic characterization program, the background geochemical characterization study, the surface water and sediment geochemical study, and the historical releases investigation

The RFP geologic characterization program (DOE 1992c) was undertaken to develop a comprehensive geologic framework that could be used to define the direction, rate, and volume of groundwater flow, delineate contaminant migration pathways and characterize potential seismic risks The study was intended to be used to formulate hydrogeologic models, design and implement groundwater monitoring programs, and plan remedial activities

The background geochemical characterization study summarizes background data for groundwater, surface water, sediments, and geological materials, and identifies preliminary statistical boundaries of background variability (DOE 1992d) Similarly, the surface water and sediment geochemical characterization study (DOE 1992e) identifies surface water and sediment characteristics and documents general geochemical trends associated with environmental contamination at RFP

The historical releases investigation was required by the Interagency Agreement (IAG 1991) to provide a complete listing of all spills, releases, and/or incidents involving hazardous substances that occurred since the inception of RFP operations Information describing individual release sites was gathered by background research, file review site visits and photography, and employee interviews Release sites including existing RFP IHSSs, were designated as potential areas of concern (DOE 1992b)

In 1992 an investigation was conducted to provide an engineering evaluation of the stability and general safety of earthen dams A3, B1, B3, and the Landfill Dam, which were constructed in the North Walnut Creek and South Walnut Creek drainages The dams study included visual reconnaissance, exploration and evaluation of subsurface conditions, analyses of data, and development of conclusions and recommendations pertaining to the condition of the dams Field and laboratory data, analyses, and conclusions and recommendations are summarized in the geotechnical engineering report (EG&G 1993a)

1.3 4 Ongoing Investigations within OU6

1 3 4 1 Sediment Sampling Program

For several years sediment samples were collected quarterly at 17 locations along North Walnut Creek, South Walnut Creek, the unnamed tributary north of North Walnut Creek, and from drainages along the north slope of the plant (DOE 1992a, Figure 2-2) However, the Sediment Sampling Program was discontinued in the fall of 1992 The existing locations were also sampled as part of the OU6 Phase I field sampling program

1.3 4 2 Surface Water Sampling Program

Surface water samples are collected monthly to monitor the water quality prior to and during off-plant site discharge Within OU6, numerous surface water sampling sites exist along the Walnut Creek drainage and within the A and B-Series Ponds (DOE 1992a, Figure 2-2) The Phase I investigation used many of the existing surface water sampling sites to collect samples for analyses These specific existing sites, along with additional Phase I surface water sampling sites, are shown on Figures 2 2-3 through 2 2-12 of this report

1 3 4 3 Groundwater Sampling Program

Groundwater samples from existing wells at RFETS including the OU6 area, are collected on a quarterly basis to monitor the groundwater quality beneath the RFETS Existing wells located in the OU6 area, are presented on Figure 3 6-1 and associated data are discussed in Section 3 6 of this report

1 4 SUMMARIES OF THE OU6 PHASE I RFI/RI WORK PLAN, TECHNICAL MEMORANDA, AND LETTER REPORT

This section presents summaries of the OU6 Work Plan, Technical Memoranda (TM) and Letter Report As stated in the IAG the iterative nature of the RFI/RI process may identify additional data requirements and analyses for many of the sites (IHSSs) at RFETS due to the unknown nature of these sites Therefore, technical memoranda shall be submitted that document the need for additional data and identify the data quality objectives (DQOs) Upon agency approval the TM are attached as amendments to the approved Work Plan

Six TM, as shown below were prepared as part of the OU6 Phase I RFI/RI

- Final OU6 Phase I RFI/RI Work Plan - Subsection 1 4 1
- Addendum to Final OU6 Phase I RFI/RI Work Plan (TM1) - Subsection 1 4 2
- Human Health Risk Assessment Exposure Scenarios (TM2) - Subsection 1 4 3
- Human Health Risk Assessment Model Descriptions (TM3) - Subsection 1 4 4
- Human Health Risk Assessment Chemicals of Concern (TM4) - Subsection 1 4 5
- Human Health Risk Assessment Toxicity Assessment (TM5) - Subsection 1 4 6
- Appendix I, Addendum No 1, Additional Pond Sediment Investigation - Subsection 1 4 7

Summaries of the technical memoranda are presented as discussed in the documents at the time they were submitted and/or approved The summaries do not present interpretations document what was implemented, nor present results

A summary of the CDPHE Letter Report "Source Area Delineation, Risk-Based Conservative Screen, and EPA Areas of Concern Delineation" (DOE 1994a) is presented in Section 1 4 8

1 4 1 Summary of the Final OU6 Phase I RFI/RI Work Plan

The OU6 Work Plan (DOE 1992a) presents the plan for the Phase I RFI/RI of the North Walnut Creek and South Walnut Creek drainages at RFETS The Work Plan includes a FSP that was designed to evaluate the presence or absence of contamination in the OU6 IHSSs

The schedule and sequence of work for completing the OU6 Phase I investigation are outlined in the Work Plan

The Work Plan presents a description of the site physical characteristics, histories, previous investigations, available information concerning contamination, and conceptual models for the IHSSs Applicable or relevant and appropriate requirements (ARARs) developed for OU6 were also presented Data needs and DQOs were established considering site characteristics and conceptual models of each IHSS The Work Plan includes a Baseline Risk Assessment Plan a Quality Assurance Addendum, and Standard Operating Procedure (SOP) Addenda.

After assessing the existing information for OU6, the following objectives for the OU6 Phase I RFI/RI were identified

- Characterize the physical and hydrogeologic setting of the IHSSs
- Assess the presence or absence of contamination at the sites
- Characterize the nature and extent of contamination at the sites if present
- Support the Phase I Baseline Risk Assessment

Data quality objectives were developed for the OU6 Phase I investigation DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI Through application of the DQO process, site-specific RFI/RI goals were established and data needs identified for achieving these goals Table 1 4-1 presents the DQOs identified in the Work Plan for the Phase I RFI/RI at OU6

1 4 2 Summary of Addendum to Final OU6 Phase I RFI/RI Work Plan (TM1)

The purpose of TM1 (DOE 1992f) was to eliminate unnecessary effort specified in the OU6 Work Plan Additionally, surface water sampling along streams and surface water flow measurements at existing gauging stations were proposed to enhance the Human Health Risk Assessment and contaminant fate and transport modeling

The TM1 revised the scope of six Phase I RFI/RI sampling activities

- Deleted five bedrock wells along North Walnut Creek

- Deleted one alluvial well immediately downgradient of each dam at Ponds A-4 and B-5
- Eliminated three proposed ambient air samplers from the field sampling effort
- Specified surface water sampling and flow measurement locations at previously established site-wide sampling sites and gauging stations
- Limited the radiation survey specified for IHSS 165 to the eastern portion of the IHSS located east of the PA fence, where the soil is not covered with gravel
- Substituted the use of a field instrument for the detection of low-energy radiation (FIDLER) instead of the high purity germanium (HPGe) instrument specified for the above radiation survey, if the HPGe instrument was not available

TM1 was approved by the agencies and amended to the Final OU6 Phase I RFI/RI Work Plan as Appendix H

1 4 3 Summary of OU6 Human Health Risk Assessment Exposure Scenarios (TM2)

TM2 (DOE 1995a) presents an evaluation of potential human exposure to contamination from OU6 in support of the baseline HHRA (Section 6 0) The objectives of TM2 are to (1) describe present and future land use scenarios (2) identify potential human receptor populations that may be exposed to contaminants from OU6 (3) determine potentially complete exposure pathways by which chemicals are transported from sources to human exposure points and (4) provide estimates of exposure parameters (e g inhalation rates and duration of exposure) The evaluation process associated with these objectives is discussed below

Review of present and future land use scenarios

A review of the current land use and activities was performed to develop a list of individuals currently exposed to contaminated media in OU6 The planned potential land use (i e agricultural, residential, or industrial) for OU6 and the surrounding area was also reviewed and a list of credible future exposed individuals was developed

Determination of potential receptors

The current and future land use scenarios were used to identify potential receptor populations (humans either onsite or offsite, who could be exposed to contaminants in OU6 media) Receptor populations include current or future workers at the site performing indoor or outdoor duties that may routinely contact contaminated media while working at the site

Determination of exposure pathways

Potential exposure pathways were evaluated for each receptor population, by using information regarding chemical source areas, chemical release mechanisms (such as volatilization to the air), and the potential of contact with the contaminated medium Examples of exposure pathways include direct ingestion of soil, inhalation of soil particulates, and ingestion of groundwater In addition, pathways for each receptor were determined to be (1) potentially complete and significant, (2) potentially complete but insignificant, or (3) negligible or incomplete Only the significant and insignificant pathways will be evaluated in the baseline HHRA

Determination of exposure parameters

Exposure parameters for each potentially complete pathway were determined for each receptor population Exposure parameters are reasonable estimates of variables used in intake calculations, including body weight, daily ingestion rates daily inhalations rates frequency and duration of exposure, and many others

1 4 4 Summary of OU6 Human Health Risk Assessment Model Descriptions (TM3)

TM3 (DOE 1994b) provides a description of groundwater, surface water and air modeling conducted for OU6 The objective of the modeling is to support the HHRA This will be accomplished by simulating the transport of chemicals of concern (COC) from OU6 to potential exposure points for human receptors under present and anticipated future site conditions

A conceptual site model (CSM) was developed to identify and evaluate the chemical source areas chemical release mechanisms environmental transport media, potential human intake routes, and potential human receptors at OU6 The purpose of the CSM is to identify human exposure pathways to be quantitatively evaluated in the HHRA Exposure pathways chosen for evaluation in the risk assessment may require fate and transport modeling to estimate chemical exposure point concentrations The following models were selected to meet the requirements and objectives of the modeling study

- The ONED3 analytical model for groundwater contaminant fate and transport Also, water balance analyses will support the ONED3 analyses

- The watershed/water quality model HSPF9 for surface water fate and transport

- The Superfund Exposure Assessment Manual (SEAM) Models for soil gas fate and transport, a box model for onsite ambient air contaminant fate and transport, and Fugitive Dust Model (FDM) for offsite ambient air contaminant fate and transport of OU6 source air emissions

Data available for use as input for the modeling activities were evaluated based on a review of previous and ongoing investigations and general literature The data currently available to estimate model input parameters were also summarized in TM3

1 4 5 Summary of OU6 Human Health Risk Assessment Chemicals of Concern (TM4)

TM4 (DOE 1994c) describes the selection process for determining COCs to be evaluated quantitatively in the baseline HHRA for OU6 and presents the selected COCs for surface soil subsurface soil groundwater stream and pond sediments and pond surface water Data from each medium were evaluated on an OU-wide basis therefore the primary contributors to risk in each medium became the OU6 COCs COCs include (1) metals and radionuclides that exceed the background range and could pose a threat to human health under assumed exposure conditions and (2) detected organic chemicals and nitrates that are environmental contaminants (i e not naturally occurring) and could pose a threat to human health under assumed exposure conditions The identification of COCs helps to focus the efforts of the

Ecological Risk Assessment, environmental transport modeling, and remedy selection A summary of selected COCs for the OU6 sampled media is presented below

	Surface Soil	Subsurface Soil	Groundwater	Pond Sediment	Pond Surface Water	Stream Sediment
Chemicals of Concern						
Aroclor-1254				X		
Benzo(a)anthracene						X
Benzo(a)pyrene		X		X		X
Benzo(b)fluoranthene		X		X		X
Bis(2-ethylhexyl)phthalate				X		
Di-n-butylphthalate					X	
Indeno(1,2,3-cd)pyrene						X
Acetone					X	
Chloroform			X		X	
1,2-Dichloroethene					X	
Methylene chloride			X			
Tetrachloroethene			X			
Trichloroethene			X		X	
Antimony	X			X		
Barium		X				
Cobalt						X
Silver	X			X		
Strontium						X
Vanadium	X			X		X
Zinc	X					X
Nitrate			X			
Americium-241	X	X	X	X		X
Plutonium-239/240	X	X	X	X		X
Uranium-233/234		X				

	Surface Soil	Subsurface Soil	Groundwater	Pond Sediment	Pond Surface Water	Stream Sediment
Uranium-238		X				
Radium-226			X			
Special-Case Chemicals						
Vinyl chloride			X			
Chemicals of Interest						
Antimony			X			
Arsenic			X			X
Beryllium			X			
Manganese			X			

TM4 briefly describes the environmental sampling and analytical program that determined the data to be collected in each medium. TM4 also describes the process for reviewing data used to identify the COCs that will be evaluated in the baseline HHRA In general, the selection of COCs were based on the following criteria

- Metals and radionuclides were compared to background levels using the Gilbert methodology (Gilbert 1993) Those analytes not exceeding background were eliminated from further consideration as COCs Those analytes exceeding background were considered potential chemicals of concern (PCOCs) unless geochemical evidence or a spatial/temporal comparison demonstrated that the analytes were not different than background Four metals (antimony arsenic beryllium, and manganese) are evaluated as chemicals of interest (COIs) in groundwater and arsenic in stream/dry sediments based on an IAG agreement COIs are evaluated in the uncertainties section (Section 6 10 6)

- Organic chemicals and nitrates that were detected above laboratory reporting limits at a frequency greater than or equal to 5 percent were considered PCOCs Organic chemicals detected at less than 5 percent frequency were evaluated as potential special case COCs as described below

- PCOCs in each medium were identified as COCs if the individual PCOC contributed more than 1 percent of the total potential risk for the medium based on the concentration/toxicity screens

- Organic chemicals detected above laboratory reporting limits at a frequency less than 5 percent were evaluated separately The chemical was identified as a special case COC if the chemical had a maximum concentration that exceeded one thousand times (1000x) the chemical-specific risk-based concentration (RBC) The RBCs used in the comparison were derived in the Rocky Flats Plant Programmatic Preliminary Remediation Goals (DOE 1994d)

1 4 6 Summary of OU6 Human Health Risk Assessment Toxicity Assessment (TM5)

TM5 (DOE 1994e) presents available toxicity factors for metals and radionuclides included in the sampling and analysis section (Section 7 0) of the Phase I RFI/RI Work Plan for OU6 (DOE 1992a) and for all organic chemicals detected in environmental media within OU6. Toxicity factors include EPA-verified or provisionally approved carcinogenic slope factors (SFs) and noncarcinogenic reference doses and reference air concentrations (RfDs and RfCs, respectively) EPA-verified toxicity factors are available on-line in the Integrated Risk Information System (IRIS) (EPA 1995a) or current year Health Effects Assessment Summary Tables (HEAST) and supplement (EPA 1994a) Provisional toxicity factors are supplied by the EPA in memoranda from the Environmental Criteria and Assessment Office

The RfD and RfC are the principal indices of toxicity for noncarcinogenic effects following oral and inhalation exposures, respectively These toxicity factors are considered to be threshold doses, below which adverse effects are not likely to occur following lifetime exposures. RfDs and RfCs incorporate a number of safety factors to ensure that they are protective of human health including sensitive subpopulations such as small children Oral RfDs were used to evaluate toxic effects from dermal contact, where appropriate, when no other chemical-specific information is available

EPA policy assumes that any exposure to a carcinogen could result in cancer, regardless of the dose Oral and inhalation SFs are used to estimate the upper-bound probability of an individual developing cancer from lifetime exposure to a potential carcinogen and are likely to overestimate risk (EPA 1989a) Where appropriate, oral SFs were used to assess carcinogenic effects due to dermal exposure

The EPA does not recommend the evaluation of noncarcinogenic effects of radionuclides because the toxic effects are considered to be insignificant when compared to the carcinogenic effects Internal SFs for ingested and inhaled radionuclides are derived by considering the energy level of the radionuclide and the residence time of the radionuclide in various body tissues External SFs for risk from exposure to radionuclides through the skin, are determined by the energy level of the radionuclide and the duration of external exposure TM5 also presents effective dose coefficients for radionuclides The dose coefficients are used to estimate the radiation dose absorbed by an individual exposed to radionuclides in OU6 The absorbed dose is then compared to the dose allowed by the EPA to determine if the radiation emitted exceeds safe levels

1 4 7 Summary of Appendix I, Addendum No 1, Additional Pond Sediment Investigations

During the Phase I RFI/RI polychlorinated biphenyls (PCBs) were detected in sediment samples from ponds in both series PCBs are common environmental contaminants released from electrical generators and transformers where they are used for electrical insulation PCBs are known to be toxic to both human health and the environment

The purpose of this document was to provide a preliminary evaluation of the potential ecotoxicological risks of the PCB-contaminated sediments in the Walnut Creek drainage and to identify additional sampling that may be needed to characterize those risks adequately Risk characterization must be adequate to support remediation decisions for the OU6 IHSSs This information was used primarily in the ERA, but was also incorporated into the HHRA and Nature and Extent sections of this report

1 4.8 Summary of the OU6 CDPHE Letter Report (Risk-Based Conservative Screen)

The CDPHE letter report presents the development of the Risk-Based Conservative Screen and the delineation of source areas used to define areas of concern (AOCs) in OU6

The CDPHE Risk-Based Conservative Screen was developed to support evaluation of contaminant source areas performed by CDPHE The screen is used to support the identification of low-hazard areas that may warrant no further action, possible high hazard areas that may warrant potential early action, and those areas which need to be evaluated in the baseline HHRA

The CDPHE Risk-Based Conservative Screen includes the following six steps

Step 1 Define PCOCs in surface soil, subsurface soil, pond sediment, stream sediment, pond surface water, and groundwater

Step 2 Identify contaminant source areas based on distribution of PCOCs

Step 3 Calculate an RBC for each PCOC in surface soil, subsurface soil, pond sediment, stream sediment, pond surface water, and groundwater

Step 4 Calculate the ratio of the maximum concentration of each PCOC to the corresponding RBC, sum the ratios for each medium in each source area.

Step 5 Apply CDPHE conservative screen decision criteria (defined in CDPHE 1994) to the RBC ratio sums for each source area

Step 6 Define AOCs for the baseline HHRA based on source areas

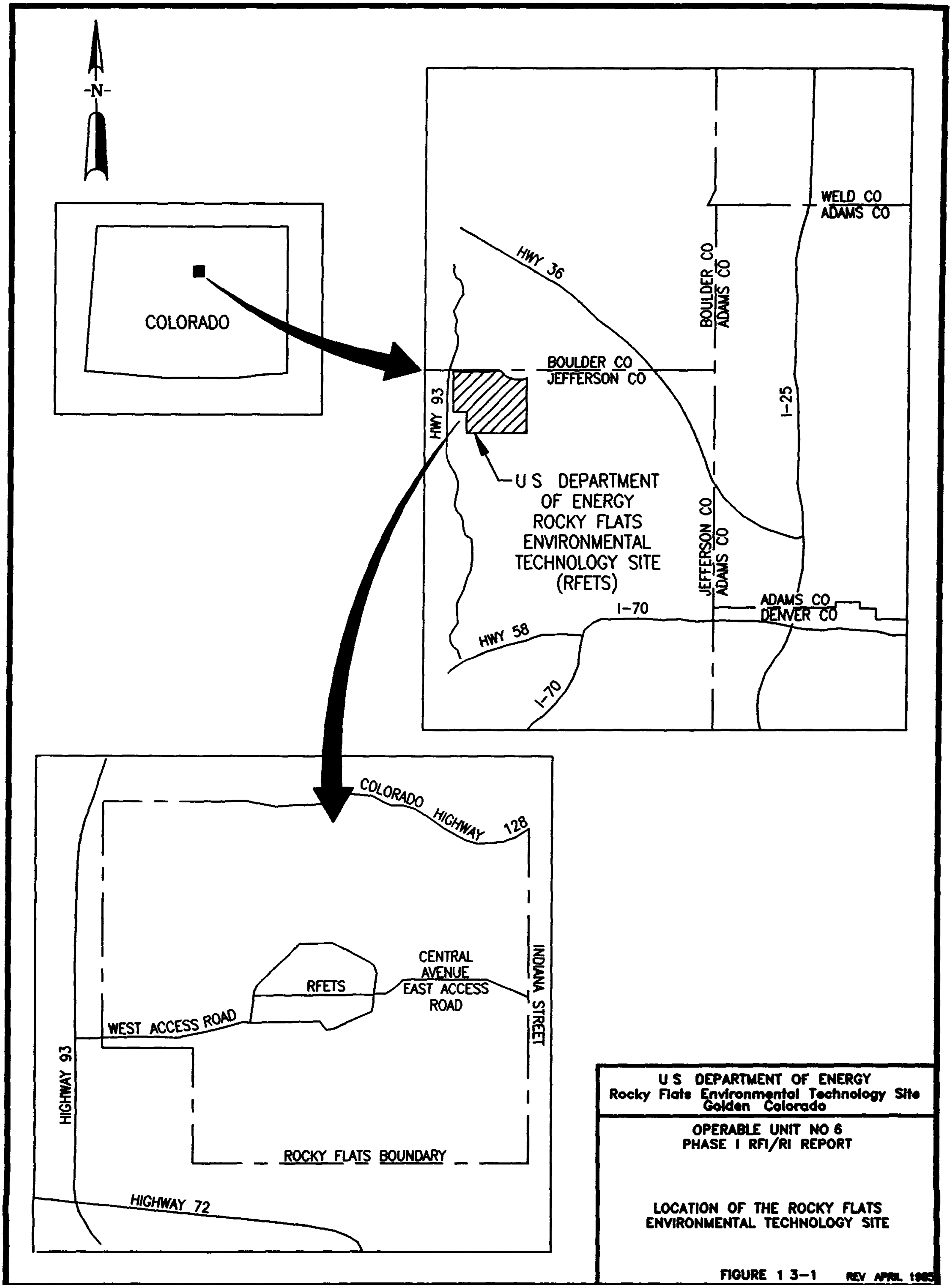
The AOCs are defined as one or several source areas that are in close proximity and can be evaluated as a unit in the HHRA In OU6, the AOCs were delineated based on the proximity of the source areas and the media evaluated in those source areas A baseline HHRA will be conducted for each AOC, focusing on the area of maximum contamination (maximum exposure area) within each AOC

TABLE 1 4-1
OU6 PHASE I RFI/RI
DATA QUALITY OBJECTIVES
(From DOE 1992a)

DATA NEEDS	SAMPLE/ANALYSIS ACTIVITY	ANALYTICAL LEVEL	DATA USE
CHARACTERIZE PHYSICAL FEATURES			
Identify extent of the Spray Fields Trenches Old Outfall Soil Dump Area and Triangle Area	Review aerial photographs • Visual inspection • Logging of boreholes	I & II	Site Characterization • Alternatives Evaluation
Characterize surface water and sediments in the ponds	Logging of sediment samples • Measurement of field parameters in water in the ponds	I & II	Site Characterization • Alternatives Evaluation
Locate and delineate extent of the Trenches	• Geophysical survey	I & II	• Site Characterization Alternatives Evaluation
CHARACTERIZE AND DELINEATE CONTAMINANT SOURCES			
Identify plumes (if present) at the Triangle Area that may lead to sources	Soil gas survey Boreholes and wells with analytical testing on samples, if plumes are identified	II (field GC) IV (analytical)	Site Characterization • Alternatives Evaluation • Risk Assessment
• Characterize sources (if present) at the Trenches and Old Outfall	Boreholes and surface samples in areas of trenches and outfall with analytical testing of samples	I & II (field) IV (analytical)	• Site Characterization Alternatives Evaluation • Risk Assessment
CHARACTERIZE NATURE AND EXTENT OF CONTAMINATION			
Characterize plumes or areas of anomalous radiation readings identified at the Triangle Area	• Boreholes and wells with analytical testing of samples, if plumes are identified	IV and V (radiological analyses)	• Site Characterization • Alternatives Evaluation • Risk Assessment

TABLE 1 4-1
OU6 PHASE I RFI/RI
DATA QUALITY OBJECTIVES
(From DOE 1992a)

DATA NEEDS	SAMPLE/ANALYSIS ACTIVITY	ANALYTICAL LEVEL	DATA USE
Characterize horizontal and vertical extent and nature of contamination at the Spray Fields, Trenches Triangle Area Soil Dump Area and Old Outfall	Boreholes and wells with analytical testing of samples	IV V (radiological analyses)	Site Characterization Alternatives Evaluation Risk Assessment
Characterize extent of radioactive materials at the Triangle Area Old Outfall Sludge Dispersal Area and Soil Dump Area	Radiation surveys	I & II	Site Characterization Health and Safety
Characterize nature and extent of contamination in surface water and sediments in Walnut Creek and the ponds	Sediment and surface water sampling with analytical testing of the samples	II (field) IV V (radiological analyses)	Site Characterization Alternatives Evaluation Risk Assessment
Characterize nature and extent of contamination in alluvial groundwater	Install and sample wells	IV V (radiological analyses)	Site Characterization Alternatives Evaluation Risk Assessment
Characterize the lateral extent of Sludge Dispersal Area	Surface soil samples with analytical testing	IV V (radiological analyses)	Site Characterization Alternatives Evaluation Risk Assessment



U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden Colorado

OPERABLE UNIT NO 6
PHASE I RFI/RI REPORT

LOCATION OF THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

FIGURE 1 3-1 REV APRIL 1995

12/15/94

OU6 FIELD INVESTIGATION

This section provides a description of the OU6 Phase I RFI/RI field investigation The field investigation, conducted in 1992 and 1993 gathered data to evaluate the nature and extent of contamination within the OU6 IHSSs if present to characterize the geology and hydrogeology of the sites and to support an evaluation of the fate and transport of contaminants for the baseline HHRA

A primary objective of the OU6 Phase I RFI/RI is to characterize the nature and extent of contamination in the soil sediment surface water and groundwater within the 20 IHSSs in OU6 These IHSSs are shown on Figure 1 3-3 The OU6 Work Plan (DOE 1992a), outlined additional objectives and presented a FSP that defined field activities intended to meet the objectives stated in the Work Plan A summary of the Work Plan is presented in Section 1 4 1 An addendum to the Work Plan, TM1 (DOE 1992f), presented a reduced scope of work for investigation at various IHSSs. A discussion of the revision of various IHSS boundaries and locations that resulted from the HRR (DOE 1992b) is discussed in Section 1 3 2

A four-staged approach for conducting the field investigations was incorporated into the FSP The four stages some or all of which were conducted at each IHSS are summarized from the FSP as follows

Stage 1 Review existing data

Stage 2 Conduct preliminary field surveys and screening activities

Stage 3 Conduct a field sampling program for soil sediment and surface water

Stage 4 Install monitoring wells and implement a groundwater sampling program

Stage 1 consisted of collecting, reviewing, and analyzing existing data for each IHSS, including aerial photographs and site records Data from other operable unit investigations that became available following preparation of the Work Plan were also compiled and evaluated, if appropriate

Stage 2 involved preliminary screening activities, including radiation surveys, a soil gas survey in the Triangle Area (IHSS 165), and an electromagnetic (EM) survey at Trenches A, B and C (IHSSs 166 1 - 166 3)

Stage 3 consisted of Phase I sampling activities for soil, sediment, and surface water at various IHSSs Soil borings were completed and sampled at nine of the IHSSs for characterization of subsurface conditions and contamination These activities provided confirmation of the Phase I preliminary screening data as well as aided the Phase I geologic and hydrogeologic characterization of the sites

Stage 4 involved the installation of nine colluvial/alluvial monitoring wells and two bedrock monitoring wells to characterize the hydrogeologic setting of selected sites and to monitor groundwater conditions beneath or downgradient of specific OU6 IHSSs As of the 4th quarter 1994 four wells (75892, 76792 77192 and 77391) remained dry and have not been developed, of the remaining seven wells, five wells (75092, 75292, 76192 76292, and 77492) were sampled after installation and development and two wells (75992 and 76992) were initially dry and sampled at a later date

Table 2 1-1 summarizes the types and numbers of field activities conducted during the OU6 Phase I investigation

2 1 OVERVIEW OF OU6 PHASE I FIELD ACTIVITIES

The OU6 Phase I field activities were conducted from the Fall of 1992 through the Spring of 1993 As discussed above, field activities were conducted in four general stages This section provides an overview of the field activities and procedures implemented for each activity associated with the four-staged approach used in the Phase I field program

Field operations for the OU6 Phase I investigation were conducted in accordance with the Work Plan (DOE 1992a) TM1 existing RFETS SOPs as contained in the Rocky Flats Environmental Management Department (EMD) SOPs Volume I Field Operations, Volume II Groundwater Volume III Geotechnical Volume IV Surface Water (EG&G 1992a) and the Environmental Management Radiological Guidelines ([EMRGs] EG&G 1991a) In some cases, modifications were made to the Work Plan, TM1 or SOPs The modifications were documented in Document Change Notices (DCNs) that explained the nature of and rationale for the changes Table 2 1-2 summarizes the SOPs utilized for the Phase I field investigation and Table 2 1-3 summarizes Work Plan and TM1 DCNs applicable to this investigation

Field activities were conducted in accordance with the Site Health and Safety Plan (HSP) (EG&G 1992b) As specified in the HSP radiation and volatile organic compound (VOC) monitoring was performed during drilling and monitoring well installation to avoid potential personnel exposure and to initiate personal protection action levels In addition, the VOC measurements were utilized as an indicator of possible VOC contamination of the cuttings and core and to identify intervals for sampling Radiation and VOC monitoring was conducted in accordance with SOPs FO 15 and FO 16

Prior to the start of field activities drilling and sampling equipment was decontaminated at the RFETS main decontamination facility in accordance with SOPs FO 03 and FO 04 Hand sampling and downhole sampling equipment was decontaminated between sampling events and at the conclusion of the field investigation prior to leaving the IHSS Downhole drilling equipment (e g , hollow-stem augers, flightless augers, drill-rods were decontaminated between boring locations Drill rigs were decontaminated between the IHSSs and at the conclusion of the drilling program Prior to decontamination and before being released offsite equipment was screened using a Ludlum 12-1a with 43-5 scintillation alpha detector and a Ludlum 31 with a 44-9 beta detector in accordance with the EMRGs Smear samples were also taken in accordance with EMRGs

2 1 1 Stage 1 Activities - Review Existing Data

Stage 1 activities consisted of reviewing the HRR (DOE 1992b), available aerial photos existing monitoring well data, and surface water and stream sediment data for each IHSS In general, Stage I activities were completed prior to performing the field work at each IHSS

2.1 2 Stage 2 Activities - Preliminary Screening

2 1 2 1 Radiation Surveys

Ground-based radiation surveys employing HPGe gamma-ray sensors were conducted from April through June, 1993 at IHSSs 141, 156 2 and 165 (area outside the PA only) These surveys were performed to evaluate whether gamma-emitting radionuclides were present in surface soils at these IHSSs The germanium sensors were spaced to provide overlapping coverage between stations for the purpose of obtaining essentially 100 percent coverage. The gamma-emitting radionuclides detected were analyzed to identify the associated isotopes. The radiation activities and results of these surveys are presented in Appendix B1

Prior to sample collection each sample site in OU6, with the exception of pond water and wet sediment sample locations, was screened for radiation using a FIDLER or a Ludlum 12-1A with an air proportional probe, in accordance with FO 16 The results of these radiation surveys were below background levels for all sites, and are summarized in Appendix B2

2.1 2 2 Soil Gas Survey

A real-time soil gas survey was conducted over the Triangle Area (IHSS 165) to evaluate whether VOCs were present in subsurface soils and to aid in the siting of boreholes Soil gas samples were collected using expendable point sampling probes The expendable points were hydraulically driven into the subsurface with 1-inch diameter probe rods Once the point reached the interval of interest, the rod was slightly retracted for sampling Polyethylene tubing was then attached to the probe rod and a vacuum was drawn to collect soil gas from the interval of interest The soil gas was collected in a 500 milliliter (ml) glass sample bulb with teflon valves and a teflon coated septa port at its center Once the sample was collected in the bulb, it was then analyzed using an onsite gas chromatograph The soil gas samples were analyzed within four hours of collection

Between collection of each soil gas sample the downhole equipment was decontaminated with a soap (liquinox) wash and rinsed with distilled water New 60 ml syringes and new polyethylene tubing were used for every soil gas sample The 500 ml glass sampling bulbs were purged with high grade helium vapor for 1 minute prior to sample collection and a new teflon coated septa port was used between each sample

An onsite Hewlett-Packard 5890 Series II gas chromatograph with a 75 meter by 0 53 millimeter (mm) internal diameter (ID) volatiles column photoionization detector and an electron capture detector (PID/ECD) were used to perform modified EPA methods 8010 and 8020 analyses of soil gas samples The target analytes included acetone chloroform, 1 2-dichloroethane (1 2-DCA) methylene chloride, toluene trichloroethene (TCE), 2-butanone, and tetrachloroethene (PCE)

The soil gas survey at IHSS 165 is discussed further in Section 2 2 5 The results of the survey are presented in Appendix B3

2 1 2 3 Geophysical Survey

A geophysical survey was performed in the vicinity of IHSSs 166 1 166 2, and 166 3 (Figure 2 1-1) to help delineate the locations and lateral extent of suspected burial trenches identified during aerial photograph review (Stage 1) The geophysical technique employed was an EM survey The EM survey measured conductivity variations between native soils and possible disturbed backfill material using a Geonics EM-31 ground conductivity meter The interpretation of the results of the EM survey, in conjunction with field observations of ground surface features were used to select the location of soil borings for the purpose of sampling suspected trench material

Boundaries for the EM survey were located by plotting bearings and distances from identifiable landmarks observed on aerial photographs and available maps Upon locating these landmarks in the field traverses were made using a Brunton compass and measuring tape to lay out baselines for the EM survey grids The identified baselines were then used to establish grid perimeters that were marked with survey pins located at 10-foot intervals along the perimeter lines The interiors of the grids were then marked at 10-foot intervals using survey pins Data collection points within the grids were identified by a survey pin

Two EM survey grids were established to cover the trenches in the three IHSSs The largest grid (Grid A) included the westernmost suspected trench locations and a smaller grid (Grid B) covered the suspected easternmost trench in IHSS 166 3

The EM survey data were collected using a station spacing of 10 feet over each grid area and recorded by digital data logger Data were collected in both the horizontal and vertical dipole modes, providing penetration depths of up to 9 feet and 18 feet, respectively Data plotting and contouring was accomplished using Geosoft® computer software Data input included the raw data, the grid spacing, and the contour interval The EM survey method and field program are summarized in Appendix B4 1 The conductivity contour maps are presented in Appendix B4 2 Anomalous zones identified on these plots were interpreted to define areas of suspected past trenching activity Section 2.2 6 further discusses the EM survey work at IHSSs 166 1, 166 2, and 166 3

2 1.3 Stage 3 Activities - Soil, Sediment, and Surface Water Sampling

2 1.3 1 Soil Borings, Soil Cores and Subsurface Soil Sampling

Soil borings were drilled at selected OU6 IHSSs, where access was feasible Subsurface soil samples were collected and analyzed to characterize the waste materials remaining in place, and to assess contaminant concentrations in the alluvium and bedrock materials directly beneath the sites The specific soil borings drilled in each IHSS are discussed further in Section 2.2 and site location survey data are contained in Appendix C1 Soil cores, referenced in IHSS 165, were drilled in the same manner as soil borings as discussed below

Soil borings were advanced using 3-1/4-inch ID hollow-stem augers, in accordance with SOP GT 02 Borings drilled within IHSSs were generally drilled through alluvium or in some cases through fill material into undisturbed soil or bedrock Samples were obtained using a 3-inch ID split-spoon sampler with a stainless steel liner for VOC sample collection VOC continuous samples were collected throughout the entire borehole depth for lithologic logging purposes in accordance with SOP GT 02 Lithologic samples were classified in the field and a preliminary borehole log was completed by the rig geologist using the Unified Soil Classification System (USCS) in accordance with SOP GT 01 If groundwater was encountered, the depth it was first encountered during drilling and the water level at the completion of drilling were recorded on the borehole log

Samples collected for lithologic logging purposes were placed in core boxes and retained for detailed logging by the project stratigrapher In IHSSs 143 156 2 165 166 1-3, 167 1, and 167 3 sieve analyses were conducted on selected soil samples to provide information on grain size distribution Lithologic logs of the OU6 Phase I borings are provided in Appendix C2 Results of the grain size analyses are discussed in Section 3 9

Samples were also collected from the boreholes for chemical analysis Figure 2 1-2 illustrates the typical sampling scheme for collection of chemical samples from soil borings Discrete 3-inch by 2 5-inch samples were collected in stainless steel liners at approximate 4-foot intervals and submitted to the laboratory for VOC analyses as required by the Work Plan on an IHSS-specific basis For those boreholes that penetrated the water table a discrete sample for VOC analysis was collected from the base of the first drive sample below the depth where saturated soil was encountered. For those boreholes that penetrated bedrock, a discrete sample for VOC analysis was collected from the base of the first drive sample within bedrock immediately below the overlying unconsolidated material In addition a discrete sample for VOC analysis was collected from any material exhibiting an elevated organic vapor monitor (OVM) reading staining, discoloration odor or any other anomaly indicative of potential contamination In addition to the discrete samples, composite samples were collected in borings at various frequencies according to the Work Plan and submitted to the laboratory for semivolatile organic compounds (SVOC), metal, pesticide, polychlorinated biphenyls (PCB), and radionuclide analysis If sandstone was encountered beneath the alluvium, the composite boring sampling continued until claystone bedrock was encountered VOC and composite boring sampling is discussed on an IHSS-specific basis in Section 2 2 of this report

Following removal from the borehole the split-spoon sampler was opened and the core was screened for radiation and VOCs using a Ludlum 12-1A and OVM respectively The VOC stainless steel liner was then removed from the split spoon sampler capped with Teflon™ tape and plastic caps, sealed with black electrical tape, labeled, sealed in Ziploc™-type bags and placed in a cooler with ice Following removal of the VOC stainless steel liner, the split-spoon sampler containing the remaining sample was closed and placed in a location out of the sun After the appropriate number of samples were collected from a borehole as described by the Work Plan, a composite sample was prepared Composite sample material consisted of a mixture of scrapings from cores from consecutive drilling intervals after it had been peeled in accordance with SOP GT 02 Composite samples were then placed in the appropriate labeled sample containers, and the containers were placed in bags in a cooler with ice Split-spoon samplers were decontaminated between individual coring runs.

For each sample submitted for chemical analysis, a corresponding radiological screen (RAD screen) sample was collected RAD screen samples were collected to analyze radiological levels to ensure that potentially radioactive analytical samples were handled and shipped appropriately as outlined in SOP FO 18 The RAD screen samples were shipped offsite and analyzed before the corresponding analytical samples were shipped offsite

Subsurface soil samples were shipped offsite for chemical analysis Table 2 1-4 is a matrix that shows the analytes or analyte groups for subsurface soil samples collected from the various IHSSs Discrete samples were analyzed for Target Compound List (TCL) VOCs Composite samples were analyzed for various analytes or analyte groups depending on the IHSS in which they were collected Table 2 1-5 lists the specific analytes associated with each analyte group referred to on Table 2 1-4, and Table 2 1-6 lists the sample containers, sample preservation, and sample holding times for the samples Analytical results for subsurface soil sample analyses are presented in Section 4 5 and are tabulated in Appendix D2.

Quality Control (QC) procedures were followed in the field for subsurface soil sampling in accordance with the EMD SOPs, the RFP Site-Wide Quality Assurance Project Plan (DOE 1992g), and the project-specific Quality Assurance Addendum (DOE 1992h) Field QC samples included equipment rinsates, duplicates, matrix spike/matrix spike duplicates, and lab replicates for radionuclide analysis Table 2 1-7 summarizes the QC sample types and sample collection/analysis frequencies for the QC samples QC sample analysis results are discussed in Section 4 2 3 and Appendix E

2 1 3 2 Surface Soil and Dry Sediment Sampling

Surface soil and dry sediment samples were collected in OU6 using the RFP sampling method in accordance with SOP GT 08 surface soil sampling This method consisted of driving a stainless steel cutting tool (Fig 2 1-3) 5 centimeters (cms) into undisturbed soil The sample within the tool cavity was then collected using a stainless steel scoop and placed in a stainless steel sample container for compositing Under the RFP method, 10 subsamples were collected for compositing from the corners and the center of two, 1-meter squares, spaced one meter apart After the 10 subsamples were collected, a representative composite sample was obtained in accordance with SOP GT 02 Sampling equipment was decontaminated between composite locations

After compositing was complete the sample was then placed in the appropriate labeled sample container and the container was placed in a plastic bag in a cooler A RAD screen sample was collected for each location RAD screen samples were collected to analyze radiological levels to ensure that potential radioactive analytical samples were handled and shipped appropriately

Surface soil samples and dry sediment samples were shipped offsite for chemical analysis Table 2 1-4 is a matrix that shows the analytes or analyte groups for surface soil samples and dry sediment samples collected from the various IHSSs Composite samples were analyzed for various analytes or analyte groups depending on the IHSS in which they were collected Table 2 1-5 lists the specific analytes associated with each analyte group referred to on Table 2 1 4 and Table 2 1-6 lists the sample containers, sample preservation, and sample holding times for the soil and dry sediment samples Analytical results for surface soil and dry sediment sample analyses are presented in Section 4 4 and are tabulated in Appendix D1

QC procedures were followed in the field for surface soil and dry sediment sampling as described for subsurface soils in Section 2 1 3 1 Table 2 1-7 summarizes the QC sample types and sample collection/analysis frequencies for the QC samples QC sample analysis results are presented in Appendix E

2 1 3.3 **Stream Sediment, Pond Sediment and Surface Water Sampling**

Stream sediment samples were collected using a 2-inch diameter core sampler with a hand driver, in accordance with SOP SW 06 The material collected was sieved in the field with a 12-inch diameter brass sieve (#10 mesh) and then composited by mixing, quartering, and mixing again Samples were then placed in the appropriate labeled sample jars The sample containers were placed in plastic bags in a cooler with ice Handling and shipping of samples were in accordance with SOP FO 13 The sampling equipment was decontaminated between sample locations

Pond sediment samples were collected in accordance with SOP SW 06 Core samples were collected with a 2 5-inch diameter polyurethane tube that was pushed into the sediment These core sediment samples were lithologically logged in accordance with the USCS (SOP GT 01) Hand dredge samples were collected when sufficient sample could not be obtained from core sampling Both core and dredge sediment samples were composited by mixing, quartering, and mixing again Samples were then placed in the appropriate labeled sample containers The sample containers were then placed in plastic bags in a cooler with ice Handling and shipping of samples were conducted in accordance with SOP FO 13

For each sediment sample, a corresponding RAD screen sample was collected, as outlined in SOP FO 18 to analyze radiological levels prior to handling and shipping the corresponding potentially radioactive analytical samples

Stream and pond sediment samples were shipped offsite for chemical analysis Table 2 1-4 provides a laboratory analytical matrix that shows the analytes or analyte groups for stream and pond sediment samples collected from the various IHSSs Composite sediment samples were analyzed for various analytes or analyte groups depending on the IHSS in which they were collected Table 2 1-5 lists the specific analytes associated with each analyte group referred to on Table 2 1-4 and Table 2 1-6 lists the sample containers, sample preservation and sample holding times for the stream and pond sediment samples Analytical results for stream and pond sediment sample analyses are presented in Section 4 8 and are tabulated in Appendix D4

QC procedures described for subsurface soil sample collection (Section 2 1 3 1) were also followed in the field for stream and pond sediment sampling Table 2 1-7 summarizes the QC sample types and sample collection/analysis frequencies for the QC samples QC sample analytical results are presented in Appendix E

Stream and pond surface water samples were collected in accordance with SOPs SW 03 and SW 08 respectively Stream samples were collected during baseflow and storm event conditions In general flumes are located at stream sampling stations Stream samples were generally collected from the center of the flume by submerging a stainless steel or Teflon™ sampling container just below the water surface and allowing the container to fill While the sample container was being filled, care was taken to minimize disturbances in the stream bed Following collection the water sample was transferred to the appropriate labeled sample containers, which were then placed in a cooler with ice Stream flows were measured immediately after water sample collection by reading the gauge height on the flumes If sampling took place at a location without a permanent flume, stream flow measurements were taken using either a portable flume a bucket and stopwatch or a pygmy flow meter Field parameter measurements (e g temperature specific conductance, pH) were then taken in accordance with SOP SW 02

Pond surface water samples were collected either from shore using a stainless steel dipper or from a boat using a Teflon™ bailer Again the samples were transferred to appropriate labeled sample containers which were then placed in a cooler with ice

Stream and pond surface water samples were shipped offsite for chemical analysis Table 2 1-4 provides a laboratory analytical matrix that shows the analytes or analyte groups for stream and pond surface water samples collected from the various IHSSs Table 2 1-5 lists the specific analytes associated with each analyte group referred to on Table 2 1-4, and Table 2 1-6 lists the sample containers, sample preservation and sample holding times for the stream and pond sediment samples Analytical results for stream and pond surface water sample analyses are presented in Section 4 7 and are tabulated in Appendix D4

QC procedures described for subsurface soil sample collection (Section 2 1 3 1) were followed in the field for stream and pond surface water sampling Table 2 1-6 summarizes the QC sample types and sample collection/analysis frequencies for the QC samples QC sample analytical results are presented in Appendix E

2 1.3 4 Soil Profiles

Three soil profiles (pits) were excavated, described, and sampled to assess the vertical distribution of plutonium and americium in the soils These pits were located in IHSSs 165, 167 3, and 216 1, with specific site details provided in Section 2.2 The soil pits were excavated in undisturbed or minimally disturbed sites, which are characterized by natural short grass prairie, pasture and valley side vegetation (Clark et al , 1980) The soil pit locations were determined using aerial photographs, soil and topographic maps, and radiological field surveys Soil samples from the three pits were collected using a modified trench method in accordance with SOP GT.07

2 1 4 Stage 4 Activities - Monitoring Well Installation and Groundwater Sampling

2 1 4 1 Monitoring Well Installation

Monitoring wells were installed in accordance with SOP GT 06 The typical construction for the monitoring wells is shown in Figure 2.1-4 In a few cases, monitoring wells were completed in boreholes drilled as part of the Stage 3 activities In general, monitoring wells were initially drilled using 3-1/4-inch ID hollow-stem augers as described in Section 2.1 3 1 Prior to well installation, the borings were reamed using 6-1/4-inch ID hollow-stem augers Monitoring wells were then completed inside of the 6-1/4-inch ID augers prior to removal of the augers. Well screens consisted of 2-inch ID Schedule 40 polyvinyl chloride (PVC) pipe with 0 01-inch machined slots Nonslotted (blank) Schedule 40 PVC riser pipe was installed above the screened interval and was used for a sediment sump below the screened interval A filter pack consisting of 16-40 silica sand was placed around the monitoring well screen A bentonite seal was placed on top of the filter pack to seal the screened interval from the rest of the borehole annulus Following placement of the bentonite seal, the remainder of the borehole annulus was grouted to ground surface Monitoring well installation information is summarized in Table 2 1-8, and construction logs are shown in Appendix C2 for each monitoring well The location and specific details of the monitoring wells drilled during the OU6 Phase I investigation are provided in Section 2 2

The above-ground completion details of the monitoring wells are depicted in Figure 2 1-5 Vented caps and vented, lockable steel casings were installed for each monitoring well In areas of heavy vegetation or traffic, 3-inch diameter steel guard posts were installed around the monitoring wells at a distance of approximately four feet radially from the surface casing Protective steel casings and guard posts, when installed, were painted with primer and enamel paint suitable for outdoor exposure

2 1 4 2 <u>Monitoring Well Development and Groundwater Sampling</u>

Following installation groundwater monitoring wells were developed and sampled under the RFETS site-wide groundwater program Monitoring well development was conducted in accordance with SOP GW 02 and groundwater sampling was conducted in accordance with SOP GW 06

Groundwater samples were shipped offsite for chemical analysis Table 2 1-4 provides a laboratory analytical matrix that shows the analytes or analyte groups for groundwater samples collected from the various IHSSs Table 2 1-5 lists the specific analytes associated with each analyte group referred to on Table 2 1-4 and Table 2 1-6 lists the sample containers sample preservation, and sample holding times for the groundwater samples Analytical results for groundwater sample analyses are presented in Section 4 6 and are tabulated in Appendix D3

QC procedures followed in the field for groundwater sampling were those included in the RFETS site-wide groundwater program QC sample analytical results are presented in Appendix E

2 1 5 Additional Phase I Investigation Activities

2 1 5 1 <u>Site Numbering</u>

Tables 2 1-9 and 2 1-10 list the RFETS-assigned site numbers and corresponding survey coordinates for sampling sites in OU6 To differentiate the type of medium sampled at a site a prefix was assigned to all sites except borings and wells The RFETS-assigned site numbers do not distinguish boring sites from monitoring well sites (e g there is no BH or

MW prefix) All sediment sample sites (i e , dry, pond and stream sediments) were designated by a "SED" prefix in the site number Surface soil sample sites (also known as soil scrapes) were designated by a "SS" prefix in the site number Surface water sample sites (i e , baseflow, storm event, and pond water samples) were assigned a "SW" prefix in the site number

2 1.5 2 Engineering Surveying

Prior to performing screening surveys, drilling and/or surface soil sampling, the specific sampling points were approximately located in the field relative to known landmarks using a compass and pacing method Following the drilling of soil borings and installation of monitoring wells, location coordinates and elevations were surveyed to a minimum relative accuracy of 0 1 feet horizontally and 0 01 feet vertically by an engineering surveyor and were reported in State Plane Coordinates For horizontal control, the surveyed point was either the center of the borehole marker or the center of the monitoring well casing cap Three elevation measurements were taken for monitoring wells the ground elevation, the top of the well casing and the top of the protective casing. Stream, dry sediment, and pond sample locations, although not surveyed, were measured from known landmarks using measuring tapes and compasses Surface soil sampling points coinciding with a borehole or monitoring well location shared survey coordinates Location coordinates for each sample collection point are listed in Tables 2 1-9 and 2 1-10. Elevations for monitoring wells are listed on Table 2 1-8 All survey data are summarized in Appendix C1

2 1.5.3 Data Management

Field and laboratory data collected during the Phase I field investigation were incorporated into the Rocky Flats Environmental Database System (RFEDS) The RFEDS is used to track, store, and retrieve project data Data were input to the RFEDS via diskettes subsequent to data validation as outlined in the Environmental Restoration Program (ERP) Quality Assurance Project Plan (QAPjP) and SOP FO 14 (Field Data Management) Hard copy reports were then generated from the system for data interpretation and evaluation

2 1 5 4 Surface Geologic Mapping and Seep Field Identification

In addition to the field investigation activities described earlier, surface geologic mapping and seep identification activities were performed to aid in the geologic and hydrogeologic interpretations for OU6

Previously published interpretations of surface geology were used to assist in geologic mapping where possible Aerial photographs were also used to identify geologic contacts, geomorphic features, historical changes in landscape, and the presence of past man-made features and activities

Surface geologic mapping within OU6 was performed during January 1994 Field mapping was performed using 1 3600 scale base maps Geological contacts were plotted onto base maps using standard field methods described in Compton (1962) Field mapping to identify groundwater discharge (seep) points within OU6 was performed on January 5 and 6 1994 Mapping of seep locations was performed using 1 3600 scale base maps The extent and shape of vegetated areas associated with groundwater seepage were recorded on base maps using methods similar to those used for geologic mapping The results of the field mapping activities are discussed in Section 3 5

2 2 SUMMARY OF FIELD INVESTIGATIONS BY IHSS

The Phase I field investigation activities completed in each of the OU6 IHSSs are described in this section The activities performed in each IHSS may have involved some or all of the four stages previously discussed in Section 2 1 For the purpose of consistency the following discussion maintains the stage numbering discussed in Section 2 1

- Stage 1 - Review existing data
- Stage 2 - Conduct preliminary field surveys and screening activities
- Stage 3 - Conduct a sampling program for soil, sediment and surface water
- Stage 4 - Installation of groundwater monitoring wells and implementation of a groundwater sampling program

The stage numbering presented in the following sections may not match stage numbers assigned in the Work Plan for particular IHSSs due to the use of the sequential numbering method for the stages in the Work Plan

Unless otherwise noted below, field activities at each IHSS were conducted in accordance with the Work Plan and/or TM1 Deviations from the Work Plan or TM1, if they occurred, are reported in the discussion for each IHSS

2 2 1 Sludge Dispersal Area (IHSS 141)

The Sludge Dispersal Area (IHSS 141) is approximately 67,000 sq ft in areal extent and lies along the eastern perimeter of the security area of RFETS (Figure 2 2-1) A detailed description of IHSS 141, including waste-related activities, is presented in Section 1 3.2 1

Investigation Stages 1 through 4 were conducted at IHSS 141 A summary of the proposed and completed Phase I investigations at IHSS 141 is presented on Table 2 2-1 and is discussed below

<u>Stage 1 - Review Existing Data</u>

A review of the HRR (DOE 1992b) and aerial photographs provided information on incidences of sludge overflow and dispersal at IHSS 141, and was used to revise the boundary for IHSS 141 (Figure 2.2-1)

<u>Stage 2 - Radiation Surveys</u>

Prior to collection of surface soil samples at IHSS 141 as part of Stage 3 (discussed below), a 17-point FIDLER radiation survey was performed for each surface soil sample location (the surface soil samples were collected on a 25-foot grid) As provided for in TM 1, this survey was performed as an alternative to the germanium survey specified in the Work Plan No anomalous radiation readings were detected in IHSS 141 during the FIDLER survey Details of the procedures for the 17-point FIDLER radiation survey are presented in the EMRGs (EG&G 1991a)

In addition to the FIDLER radiation survey a germanium survey was conducted over IHSS 141 from April 22 to June 3, 1993 This survey was conducted after the Stage 3 soil sampling activities were completed in IHSS 141 Figure 2 2-2 shows the survey points used for the germanium survey The germanium survey is briefly discussed in Section 2 1 2 1 and the results of the germanium survey are presented in Appendix B1

Stage 3 - Surface Soil Sampling

The Work Plan specified that surface soil samples be collected to a depth of 5 cm (0 2 feet) on a 25-foot grid spacing over IHSS 141 according to the RFP method, described in SOP GT 08 Surface soil samples were also to be collected from areas of anomalous radiation readings located during the radiation survey

Surface soil samples were collected on a 25-foot grid spacing, except in areas with existing roads or buildings as specified in the Work Plan (Figure 2.2-1) Surface soil samples were collected using the procedures discussed in Section 2 1 3 2 A total of 40 surface soil samples were collected (Table 2 1-4) No surface soil samples were collected in gravel or asphalt-paved areas or beneath buildings Since no anomalous radiation readings were detected during the FIDLER radiation survey, no additional surface soil samples were collected

Surface soil samples from IHSS 141 were analyzed for the parameters shown on Table 2 1-4 and 2 1-5 Laboratory analytical results are presented in Appendix D1 and are discussed in Section 4 4 1

Stage 4 - Monitoring Well Installation, Development, and Sampling

One monitoring well, 75992 was installed to collect groundwater samples from the colluvium The monitoring well installation procedures are discussed in Section 2 1 4 1 Monitoring well 75992, located east of the southeast corner of IHSS 141 (Figure 2 2-1), is in an apparent downgradient position relative to IHSS 141, based on a review of hydrogeologic conditions at the site During the drilling of monitoring well 75992 colluvial material was encountered overlying claystone bedrock Colluvial material lies within the same hydrostratigraphic unit as Rocky Flats Alluvium The colluvial/alluvial hydrostratigraphic relationship is discussed in detail in Section 3 6 of this report The well encountered the top of bedrock at 10 feet and extends to a total depth of 15 5 feet The well is screened in colluvial material from a depth of 5 feet to 10 feet. Well installation and development procedures are discussed in Sections 2 1 4 1 and 2 1 4 2 Monitoring well installation information is summarized in Table 2 1-8 and presented in Appendix C2 1 Since the bedrock unit underlying the colluvium was not sandstone, a bedrock monitoring well was not installed at this location

Well 75992 was initially a dry well following installation, however has since been developed and sampled in 1994

<u>Deviations from the Work Plan</u>

- No alluvial material was encountered in the drilling of monitoring well boring 75992 The monitoring well was installed and is screened in colluvium (Table 2 2-1)

2 2 2 A and B-Series Ponds (IHSSs 142 1 through 142 9), W&I Pond (IHSS 142 12), and Walnut Creek Drainages (Non-IHSS)

The A and B-Series and W & I Ponds (IHSSs 142 1-9 and 12) are located within the South Walnut Creek and North Walnut Creek drainages (Figure 1 3-3) Detailed descriptions of the pond IHSSs, including pond capacities, are presented in Sections 1 3 2 3 through 1 3.2 5

Investigation Stages 1, 3 and 4 were conducted for this IHSS group A summary of the proposed and completed Phase I investigations at IHSSs 142 1-9 and 12 is presented on Table 2.2-1, and is discussed below

<u>Stage 1 - Review Existing Data</u>

A review of the RFETS site-wide surface water and sediment monitoring programs in the Walnut Creek drainages was performed to assess potential overlap with the OU6 Phase I field program at IHSSs 142 1-9 and 12 Based on this review and consultations between EG&G, DOE, CDH, and EPA, stream surface water and stream sediment sampling locations specified in the Work Plan were replaced by existing RFETS monitoring program sampling stations along the Walnut Creek drainages and the major tributaries to Walnut Creek (see TM1) Pond surface water and pond sediment sampling locations however, did not change from those stated in the Work Plan In addition as specified in the Work Plan the report entitled "Trends in Rocky Flats Surface Water Monitoring" (DOE 1986c) and other data pertaining to the ponds were transmitted by DOE to the EPA and CDPHE

Stage 3 - Surface Water and Sediment Samples

Surface water samples and wet sediment samples were collected from each of the four A-Series and five B-Series Ponds, and the W&I Pond, as summarized in Table 2 2-2 and shown on Figures 2 2-3 through 2 2-12 In addition, dry sediment samples were also collected in the upstream areas for each of the A and B-Series Ponds Surface water and sediment sampling procedures are discussed in Sections 2.1 3 2 and 2 1 3 3

A total of 51 composite surface water samples were collected from the A and B-Series Ponds, and the W&I Pond The composite sample was collected through the entire vertical water column Five surface water samples were collected from each of the ponds (50 total), with one additional sample collected from the deepest part of Pond B-2 (SW62892) At surface water site SW62892, a stratified layer was detected at 4 5 feet therefore a sample was taken above and below the 4 5-foot depth Water sampling points at each pond shown on Figures 2 2-3 through 2 2-12, were selected by the following criteria

- One composite sample collected from the deepest part of the pond
- One composite sample collected near the influent of the pond
- One composite sample collected near the effluent of the pond
- Two composite samples collected from randomly selected locations in each pond

A total of 57 wet sediment samples were collected from the A and B-Series Ponds and the W&I Pond One composite sediment sample was collected at each sampling site, unless the sediment thickness was greater than 2 feet in which case an additional sample was collected below 2 feet The wet sediment samples were collected at five sampling points in each pond as follows

- One or more composite samples (depending on the depth of sediment) from the deepest part of the pond

- One composite sample near the influent of the pond

- One or more composite samples (depending on the depth of sediment) from each of the three randomly selected locations in the pond

In addition to the composited wet sediment samples collected for laboratory analysis, a separate set of sediment samples were collected at 5 cm vertical intervals from the sediment core taken in the deepest part of each pond A gamma radiation screen was performed on these sediment samples using a FIDLER The results from the gamma radiation screening are summarized in Appendix B5

The randomly selected pond surface water and sediment sampling locations were located using a random number generation approach The first step in this approach was to estimate pond surface areas based on engineering survey data or field mapping The estimated surface area of each pond was then gridded using a 5-foot by 5-foot grid spacing, and a unique numeric designation was assigned to each grid square The random sampling locations were then selected based on the grid square designations output from the random number generator Three random sites were selected for each pond (Figures 2 2-3 through 2 2-12) The first two random sites selected for each pond were used for both surface water and sediment sampling The third random site selected for each pond was only used for sediment sampling

In addition to the wet sediment samples, two dry sediment samples were collected from the upstream areas of each A and B-Series Pond The dry sediment sample locations (18 total) are shown on Figures 2 2-3 through 2 2-11

In addition to surface water and sediment sampling within the pond IHSSs, stream surface water and sediment sampling was also conducted in the Walnut Creek drainages (non-IHSS areas) during two sampling events During the first event in April 1993, one set of surface water samples was collected to assess stream base flow conditions A second set of surface water samples was collected during a spring storm event on May 17 1993 to assess storm event conditions The stream sediment samples were collected in May 1993 Figure 2 2-13 shows the sites where stream surface water and sediment samples were collected The stream sampling sites were jointly selected by DOE, EG&G, CDPHE and EPA as discussed in TM1 A majority of the sampling sites are existing stations presently monitored under either storm water monitoring programs or the RFETS site-wide monitoring program Survey coordinates for stream sampling sites are presented on Table 2 1-10.

Pond and stream surface water and sediment sampling procedures are presented in Section 2 1 3 3 Sediment samples were lithologically logged using the USCS During both stream surface water sampling events stream flow measurements were recorded for each station and are summarized in Table 2 2-3 Pond and stream surface water and sediment samples submitted for laboratory analysis were analyzed for the analytes or analyte groups listed in Tables 2 1-4 and 2 1-5 Only stream surface water samples collected during the baseflow sampling event were analyzed for aquatic toxicity as specified in DCN 93 01 of TM1 The analytical data for surface water and sediment samples are presented in Appendix D4 and are discussed in Sections 4 7 and 4 8

Deviations from TM1

Deviations from TM1 that occurred during the field activities are summarized in Table 2 2-1 The deviations were

- As summarized in Table 2 2-3 several surface water sampling locations were dry therefore, these locations were not sampled as specified in TM1

Stage 4 - Monitoring Well Installation, Development, and Sampling

Two monitoring wells were installed, one each in IHSSs 142 4 and 142 9, to allow collection of groundwater samples downgradient of Ponds A-4 and B-5 respectively Monitoring wells 75092 and 75292 were located at the base of A-4 and B-5 pond dams respectively (Figures 2 2-6 and 2 2-11)

During the drilling of well 75092, a saturated sandstone/siltstone was encountered beneath the alluvium at a depth of 7 2 feet The well was completed as a bedrock well to a total depth of 16 7 feet and screened across the sandstone/siltstone interval from 7 2 feet to 14 7 feet Because existing alluvial well 41091 was in close proximity to the alluvial well location specified in TM1, it was decided that well 41091 would adequately meet the TM1 requirements for an alluvial well to be installed downgradient of Pond A-4. Alluvial well 41091 lies 150 feet northeast of well 75092 (Figure 2.2-6) Evaluation of the borehole log for well 41091 indicates that the well was drilled to a total depth of 13 feet and is screened across Rocky Flats Alluvium from a depth of 7 8 feet to 10 feet

Well 75292 was drilled to a total depth of 13.6 feet and was screened in Rocky Flats Alluvium from 5 6 feet to 7 6 feet The uppermost bedrock unit underlying the alluvium was not a sandstone, therefore, a bedrock monitoring well was not installed at this location in accordance with TM1 Monitoring well construction information is summarized in Table 2 1-8 and presented in Appendixes C2 2 and C2.3

Following installation and development of wells 75092 and 75292 groundwater samples were collected and analyzed for the analytical parameters listed on Tables 2 1-4 and 2 1-5 Groundwater sampling procedures are discussed in Section 2 1 4 2 The analytical results for these wells were not received from RFEDS within the data window between first quarter, 1991 through fourth quarter, 1993, ~~and therefore~~, are not included in this report

Deviation from TM1

- An alluvial well was not installed at a location near the base of the A-4 Pond dam, as specified in TM1 Existing well 41091, which is in close proximity, was already present to monitor the alluvium (Table 2 2-1)

2 2.3 Old Outfall Area (IHSS 143)

The Old Outfall Area (IHSS 143) is located northwest of Building 771 (the laundry facility) within the PA (Figure 1 3-3, page 1 of 2) A detailed description of IHSS 143, including waste-related activities is presented in Section 1 3 2 6

Investigation Stages 1 through 4 were conducted at IHSS 143 A summary of the proposed and completed Phase I investigations at IHSS 143 is presented on Table 2 2-1 and is discussed below

Stage 1 - Review Existing Data

Historical summaries of IHSS 143 are provided in the Work Plan in the HRR, as well as Section 1 3 2 6 of this report Examination of aerial photographs (dated 8/1971, 10/1975, 6/1980, and 5/1986) and a review of plant drawings and reports from 1971 and 1973 indicate that the Old Outfall Area is located approximately 50 feet north of the IHSS area identified in the HRR (Figure 2 2-14) The Old Outfall Area was located in the field during the Phase I investigation by measuring distances and bearings from known landmarks (e g Building 771) identified in the aerial photographs and plant drawings

Stage 2 - Radiation Survey

Prior to intrusive activity at each sampling site at IHSS 143 during Stage 3 (discussed below), a 17-point FIDLER radiation survey was performed at each surface soil location and each soil boring location The survey was conducted in accordance with the EMRGs (EG&G 1991a) No anomalous radiation readings were detected during the survey Results from the surveyed sites are listed in Appendix B2

Stage 3 - Surface Soil Samples and Soil Borings

Soil borings were drilled in the Old Outfall Area at selected locations identified during the Stage 1 activities These soil borings were located by laying out a grid with 20-foot spacing and identifying grid points for drilling that were accessible and not blocked by above-ground and below-ground utilities or other obstructions (e g , the PA security fence or paved access roads) A total of six soil boring locations were drilled in a cluster as a result of limited surface area free of obstruction in the Old Outfall Area One soil boring 77492 was later converted to an alluvial monitoring well and is discussed below In addition to the six borings in the Old Outfall Area, a seventh boring (60692) was drilled southwest of the east culvert The boring locations are listed on Table 2 1-9 are shown on Figure 2 2-14

Four of the soil boring sites were randomly selected for collection of surface soils The surface soil sampling sites are shown in Figure 2 2-14 Surface soil sampling procedures are discussed in Section 2 1 3 2

Up to 10 feet of fill covers the original soil surface in the Old Outfall Area, therefore soil borings were drilled through the fill to the top of the pre-fill surface At each soil boring location a sample was collected from the interval from the top of the pre-fill surface to 2 inches below the pre-fill surface and composite samples were collected from the interval from 2 to 24 inches below the pre-fill surface One additional composite sample was collected from the entire fill section of boring 60092 Soil boring procedures are discussed in Section 2 1 3 1

During the drilling of boring 60292, a soil sample was collected from a depth interval of 0 feet to 2 feet for grain size analysis The results of the analysis are discussed in Section 3 9 5 2 and presented on Table 3 5-3

Surface and subsurface soil samples from IHSS 143 were analyzed for the parameters listed in Tables 2 1-4 and 2 1-5 The analytical data are presented in Appendixes D1 and D2, and are discussed in Sections 4 4 2 and 4 5 3

Deviations from the Work Plan

- The Work Plan specified drilling within IHSS 143 As discussed above, based on a Stage 1 review of historical aerial photographs and site plans, the actual location of the Old Outfall Area is approximately 50 feet north of the northern boundary of IHSS 143 as defined in the HRR (DOE 1992b) The soil borings were drilled in the Old Outfall Area as located from the review of historical aerial photographs and plans and were located in the field by measuring distances and bearings from existing landmarks identified on the aerial photographs and plans

- The Work Plan specified that borings were to be drilled in IHSS 143 on a 20-foot grid spacing except under buildings As discussed above, numerous above-ground and below-ground utilities and other obstructions (e g the PA

- fence and paved access roads) limited drilling in a number of the grid points Therefore, soil borings were only drilled where accessible

- The Work Plan specified the placement of a boring east of the east culvert Due to underground utilities roadways and security fences the boring was drilled west of the east culvert

<u>Stage 4 - Monitoring Well</u>

One monitoring well 77492 was installed downgradient of the Old Outfall Area to allow for collection of groundwater samples from the saturated alluvium (Figure 2 2-14) The well was installed in one of the Old Outfall Area soil borings drilled to total depth of 24 1 feet and was screened in the Rocky Flats Alluvium across a depth interval from 12 1 feet to 22 1 feet Well installation and development procedures are discussed in Sections 2 1 4 1 and 2 1 4 2 Details of the monitoring well construction are summarized on Table 2 1-8 and are shown in Appendix C2 4

Following installation and development, groundwater samples were collected and analyzed for the parameters listed in Tables 2 1-4 and 2 1-5 Groundwater sampling procedures are discussed in Section 2 1 4 2 The analytical results are presented in Appendix D3 and are discussed in Section 4 6 2 6

2 2 4 Soil Dump Area (IHSS 156 2)

The Soil Dump Area (IHSS 156 2) is located on the west end of the interfluve that separates North Walnut Creek and South Walnut Creek in the vicinity of the A and B-Series Ponds (Figure 2 2-15) The buffer zone access road to the A and B-Series Ponds is located in the western portion of IHSS 156 2 A detailed description of IHSS 156 2 including waste-related activities is presented in Section 1 3 2 7

Investigation Stages 1 through 4 were conducted at IHSS 156 2 A summary of the proposed and completed Phase I investigations at IHSS 156 2 is presented on Table 2 2-1, and is discussed below

Stage 1 - Review Aerial Photographs

A review of aerial photographs (dated 8/6/71 and 10/5/83) showed that the fill materials at IHSS 156 2 were placed sometime between 1971 and 1983, and that the area of fill was somewhat larger than the previously defined boundaries for IHSS 156 2 Figure 2 2-15 shows the identified boundaries for IHSS 156 2 based on the HRR (DOE 1992b)

Stage 2 - Radiation Survey

Prior to collection of surface and subsurface soil samples at IHSS 156 2 during Stage 3 (discussed below), a 17-point FIDLER radiation survey was performed for each surface soil, soil boring, and monitoring well location No anomalous radiation readings were detected in IHSS 156 2 during the FIDLER survey Details of the procedures for the 17-point FIDLER radiation survey are presented in the EMRGs (EG&G 1991a) Radiation survey results are listed in Appendix B2

In addition to the FIDLER radiation surveys, a germanium survey was conducted over IHSS 156 2 from April 22 to June 3, 1993 This survey was conducted after the Stage 3 soil sampling activities were completed in IHSS 156 2 Figure 2 2-2 shows the radiation survey points used for the germanium survey The procedures used for the germanium survey are presented in Section 2 1 2 1, and the results of the germanium survey are contained in Appendix B1 Based on the survey results, no additional radiation investigation was required as stated in the Work Plan (DOE 1992a)

Deviations from TM1

- The FIDLER survey was conducted prior to intrusive activities related to surface soil sampling and drilling soil borings The germanium survey was performed after the field sampling, on April 22 through June 3, 1993 (Table 2 2-1)

Stage 3 - Surface Soil Samples and Soil Borings

Surface soil samples were collected on a 150-foot grid spacing over the Soil Dump Area (Figure 2 2-15) A total of 22 surface soil samples were collected to a depth of 2 inches No samples were collected in gravel or asphalt-paved areas Surface soil sampling procedures are discussed in Section 2 1 3 2

A total of 22 soil borings were drilled on the same 150-foot grid used for the surface soil sampling (Figure 2 2-15) Subsurface soil sampling procedures are discussed in Section 2 1 3 1 The soil borings were drilled to a depth of three feet into the undisturbed soil beneath the fill surface Samples were taken continuously in these soil borings and were composited from each 6-foot interval in the fill material Where the fill material was less than 6 feet thick, the entire fill interval was composited In addition a 3-foot composite was taken of the undisturbed soil underlying the fill surface in each soil boring

Two soil samples were collected from a depth interval of 0 feet to 2 feet in borings 73992 and 74192 for grain size analysis Results of the grain size analyses are discussed in Section 3 9 6 2 and presented on Table 3 5-3

Surface and subsurface soil samples collected from IHSS 156 2 were analyzed for the parameters listed in Tables 2 1-4 and 2 1-5 Analytical results are presented in Appendixes D1 and D2, and discussed in Sections 4 4 3 1 and 4 5 4 1

Deviations from Work Plan

- No samples were collected in gravel or asphalt-paved areas (Table 2 2-1)

Stage 4 - Monitoring Well

One monitoring well 75892 was installed in the western half of IHSS 156 2 for collection of groundwater samples from the saturated alluvium (Figure 2 2-15) The boring for well installation was drilled into bedrock to a total depth of 14 6 feet The well was screened in the Rocky Flats Alluvium across a depth interval of 4 3 feet to 7 3 feet Since no sandstone unit was encountered in the bedrock underlying the alluvium a bedrock monitoring well was not installed at this location Monitoring well installation procedures are discussed in Section 2 1 4 1 Monitoring well construction information is summarized on Table 2 1-8 and presented in Appendix C2 5

As of the 4th quarter 1994, well 75892 remained dry and has not yet been developed.

2 2.5 Triangle Area (IHSS 165)

The Triangle Area (IHSS 165) is located in the eastern portion of the PA, just east of the Solar Evaporation Ponds (Figures 1 3-3, page 1 of 2) A detailed description of IHSS 165 including waste-related activities, is presented in Section 1 3 2 8

Investigation Stages 1 through 4 were conducted at IHSS 165 A summary of the proposed and completed Phase I investigations at IHSS 165 is presented on Table 2 2-1, and is discussed below

Stage 1 - Review Aerial Photographs

Aerial photographs from 1953, 1964, 1969 1971 and 1983, were reviewed to evaluate the extent of the drum storage area in the vicinity of IHSS 165 The 1971 aerial photograph shows equipment storage to the west of the original IHSS 165 boundary The revised IHSS boundary identified in the HRR (DOE 1992b) was expanded to the west to incorporate this storage area Figures 2 2-16 through 2 2-18 show the revised HRR boundaries for IHSS 165

Reports and/or documents concerning radiometric surveys conducted within the Triangle Area between 1975 and 1983 were transmitted by DOE to the EPA and CDPHE, as specified by the Work Plan.

Stage 2 - Radiation and Soil Gas Surveys

Prior to collection of surface and subsurface soil samples at IHSS 165 during Stage 3 (discussed below), a 17-point FIDLER radiation survey was performed for each location to be sampled No anomalous radiation readings were detected in IHSS 165 during the FIDLER survey Details of the procedures for the 17-point FIDLER radiation survey are presented in the EMRGs (EG&G 1991a) Radiation survey results are presented in Appendix B2

In addition to the FIDLER radiation surveys a germanium survey was conducted from April 22 to June 3, 1993 over the portion of IHSS 165 outside the PA This survey was conducted after the Stage 3 soil sampling activities were completed in IHSS 165 Figure 2 2-2 shows the radiation survey points used for the germanium survey The procedures used for the germanium survey are presented in Section 2 1 2 1 The results of the germanium survey are contained in Appendix B1 Based on the survey results, no additional radiation investigation was required as stated in the Work Plan (DOE 1992a)

A real-time soil gas survey was conducted October 9-21, 1992 over the Triangle Area (Figure 2 2-16) to evaluate the presence or absence of VOCs Soil gas survey sites were laid out using an approximate 100-foot grid spacing as specified in the Work Plan However a number of the site locations had to be adjusted because of the presence of large amounts of construction debris and equipment stockpiled in IHSS 165 inside the PA In addition, two sites could not be sampled because they were obstructed by the PA decontamination pad

A total of 31 survey sites were sampled during the soil gas survey The results for all survey sites were below the detection limit with the exception of one site (SGS70392) along the western boundary of IHSS 165 which had a detection of carbon tetrachloride (CCl_4) at 8 0 micrograms per liter (μg/l) The soil gas sampling and analytical procedures are discussed in Section 2 1 2 2 Data from the soil gas survey are presented in Appendix B3

<u>Deviations from TM1 and Work Plan</u>

The following deviations from TM1 occurred during the Stage 2 activities at IHSS 165

- The FIDLER survey (conducted to replace the germanium survey) was performed on an approximate spacing of 40 feet rather than the 25-foot spacing specified in TM1 However, the germanium survey was conducted April 22 through June 3 1993

- A total of 31 soil gas samples were collected and analyzed instead of the 56 specified in the Work Plan Because of the irregular triangular shape of IHSS 165, the actual number of 100-foot spaced grid points that fall within or near the boundaries of the IHSS is about 31 Two grid points within the IHSS were obstructed by the PA decontamination pad and could not be sampled, and were replaced by two points outside of the IHSS boundary (SGS69792 and SGS71692)

- The SGS grid spacing was not reduced in an area around SGS70392, a sample site with a CCl_4 detection of 8 μg/l

Stage 3 - Surface Soil Samples, Soil Cores, Soil Profile Pit and Soil Borings

Fifteen surface soil sampling sites were randomly selected from the soil gas grid locations The 100-foot spaced soil gas grid was used for the surface soil sampling instead of the 70-foot spaced grid specified in TM1 because the presence of large amounts of construction debris and stockpiled material in IHSS 165 inside the PA made sampling on a 70-foot grid impossible The surface soil samples were collected from native soil or fill material If gravel was present at the surface, it was removed prior to sampling Surface soil sampling procedures are discussed in Section 2.1 3 2 The surface soil sampling sites are listed on Table 2 1-9 and are shown on Figure 2.2-17

Four soil cores were collected from random locations within the soil gas grid to confirm the results of the soil gas survey (Figure 2 2-18) The soil cores were collected at the same depth as the associated soil gas samples Soil coring procedures are discussed in Section 2 1 3 1

Although plumes were not identified, nine soil borings were drilled within the survey grid to a depth of three feet into weathered bedrock (Figure 2 2-18) The boring depths ranged from 12 0 feet to 23 8 feet In each boring, discrete samples for VOC analyses were collected at 2-foot increments and composite samples for SVOC, metal, and radionuclide analyses were collected at 6-foot intervals

Durıng the drıllıng of borıng 72292, a soıl sample was collected from a depth ınterval of 0 feet to 2 feet for graın sıze analysıs Graın sıze analysıs results are dıscussed ın Sectıon 3 9 7 2 and presented on Table 3 5-3

One stream sedıment sample was collected near surface water statıon SW-091B, as shown on Fıgure 2 2-13 Stream sedıment samplıng procedures are dıscussed ın Sectıon 2 1 3 3

Addıtıonally a soıl profile pıt was excavated descrıbed and sampled ın the eastern portıon of IHSS 165, as shown on Fıgure 2 2-17 Soıl samples were collected ın accordance wıth SOP GT 07

Surface soıl samples, soıl core samples, and subsurface soıl samples from borıngs were analyzed for the parameters lısted ın Tables 2.1-4 and 2 1-5 The analytıcal results are reported ın Appendıxes D1 and D2 and are dıscussed ın Sectıons 4 4 4 2 and 4 5 5 2

Devıatıons from the Work Plan

- Borıng 72892 was specified ın the Work Plan to be drılled 3 feet ınto bedrock At 12 4 feet, 1 8 feet ınto bedrock, the drıll rıg encountered refusal and could not contınue through the next 1 2 feet to reach the 3-foot requırement The borıng was completed at the 12 4 foot depth

Stage 4 - Monıtorıng Wells

Two monıtorıng wells, 76192 and 76292 were ınstalled to allow collectıon of groundwater samples wıthın IHSS 165 (Fıgure 2 2-18) Monıtorıng well 76192 was ınstalled east of the PA securıty fence area and was screened ın the Rocky Flats Alluvıum across a depth ınterval of 4 feet to 6 feet The second well 76292 was ınstalled ınsıde the PA The Work Plan called for the borehole for thıs well to be drılled 20 feet ınto bedrock and the well to be completed as an alluvıal well If a sandstone was encountered ın the bedrock a second well was to be ınstalled to monıtor the bedrock When the borehole for 76292 was drılled, ıt extended to a depth of about 20 feet and extended approxımately 12 feet ınto bedrock, where sandstone was encountered Because a sandstone was encountered, the borehole was completed as a sandstone bedrock monıtorıng well screened across a depth ınterval of about

9 feet to 19 feet This screened interval included most of a moist sandstone interval from 8 5 feet to 13 6 feet observed during drilling of the borehole An alluvial monitoring well was not installed at this location because existing monitoring well 2986 lies approximately 100 feet south of well 76292 (Figure 2 2-18) Well 2986 was drilled to a total depth of 22 5 feet during a previous investigation and is screened through Rocky Flats Alluvium from 2.8 feet to 8 8 feet This well satisfied the requirements of an alluvial well in IHSS 165 as specified in the Work Plan Monitoring well installation procedures are discussed in Section 2 1 4 1 Monitoring well construction details are summarized on Table 2 1-8 and are shown in Appendix C2 6

Following installation and development, groundwater samples were collected from the monitoring wells and were analyzed for the analytes listed in Tables 2 1-4 and 2 1-5 The analytical results are reported in Appendix D3 and are discussed in Section 4 6 2 4

2.2 6 Trenches A, B, and C (IHSSs 166.1-3)

Trenches A, B, and C (IHSSs 166 1, 166 2, and 166 3, respectively) are located in the northern part of OU6, south of the Landfill Pond (Figure 1 3-3, page 1 of 2) Detailed descriptions of IHSSs 166.1-3 including waste-related activities are presented in Section 1 3 2 9

Investigation Stages 1 through 4 were conducted at IHSSs 166 1-3 A summary of the proposed and completed Phase I investigations at IHSSs 166 1-3 are presented on Table 2 2-1, and are discussed below

Stage 1 - Review Aerial Photographs

Aerial photographs from 1964 and 1969 were reviewed to identify the locations of the four trenches in IHSS 166 The 1964 photograph provided the clearest view of the trench locations and was used to locate the geophysical survey grids Following the geophysical surveys, the photograph and the results of the survey were used to locate the borings for IHSSs 166 1-3

Stage 2 - Geophysical Survey

An EM-31 survey was conducted from October 5 through 14 1992 in the area of IHSSs 166 1 166 2 and 166 3 to help delineate the locations of suspected burial trenches identified during aerial photo review A discussion of the EM survey method and field program is presented in Appendix B4 1, and the conductivity contour maps are presented in Appendix B4 2

Two EM survey grids were established to include each of the trenches within the IHSSs The larger grid (Grid A) to the west covers all of the suspected trench locations except the easternmost trench in IHSS 166 3, which is covered with Grid B Over each grid area, EM data were collected in both the vertical and horizontal dipole modes using a 10-foot grid station spacing The two modes of operation provided for penetration depths of 9 feet and 18 feet, respectively All of the EM data were plotted and contoured using a computer software package that allows for color-enhanced output. The interpretation of the EM results (Appendix B4) in conjunction with field observations facilitated the placement of soil borings within the suspected trenches, thus allowing sampling of buried trench materials, if present Several of the anomalous conductivity zones identified were interpreted to define areas of suspected trenching activity

Prior to collection of subsurface soil samples at IHSSs 166 1-3, during Stage 3 (discussed below) a 17-point FIDLER radiation survey was performed for each soil boring location No anomalous radiation readings were detected in IHSS 166 1-3 during the FIDLER survey Details of the procedures for the 17-point FIDLER radiation survey are presented in the EMRGs (EG&G 1991a) Radiation survey results are listed in Appendix B2

Stage 3 - Soil Borings

Based on the results of aerial photo review and the geophysical study a total of 26 borings were drilled in the trenches along the approximate trench axes at roughly 25-foot intervals as shown in Figure 2 2-19 The borings were terminated 5 feet below the bottom of each trench Eight borings were drilled in Trench A seven borings drilled in Trench B and six and five in the western and eastern components of Trench C respectively Subsequent to drilling the eastern portion of Trench C the IHSS location was revised and relocated south of the borings Samples were taken continuously in the soil borings described above Discrete samples were collected at 2-foot intervals and composite samples were taken at every 6-foot interval A discussion of subsurface soil sampling is presented in Section 2 1 3 1

Three soil samples were collected from a depth interval of 0 feet to 2 feet in borings 66892, 67692, and 68692, for grain size analysis Results of these analyses are discussed in Section 3 9 8 2 and presented on Table 3 5-3 Subsurface soil samples from IHSSs 166 1-3 were analyzed for the parameters listed in Tables 2 1-4 and 2 1-5 The analytical results are reported in Appendix D2 and are discussed in Section 4 5 1

Stage 4 - Monitoring Wells

Monitoring well 77392 was installed about 300 feet east of the easternmost soil boring in Trench B (Figure 2 2-19) The borehole for well 77392 was drilled to a total depth of 13 8 feet, and was screened in the Rocky Flats Alluvium over a depth interval of 3 9 feet to 6 9 feet Monitoring well 76992 was installed about 70 feet northeast of the easternmost soil boring in the eastern Trench C The borehole for well 76992 was drilled to a total depth of 15 5 feet, and was screened in the Rocky Flats Alluvium over a depth interval of 3 4 feet to 9 4 feet Since no sandstone was encountered in the bedrock underlying the alluvium at either location, no bedrock monitoring wells were installed Monitoring well installation procedures are discussed in Section 2 1.4.1. Well construction details are summarized on Table 2 1-8 and are shown in Appendixes C2 7 through C2 9

As of the 4th quarter 1994, well 77392 remained dry and has not been developed Well 76992 was initially dry following installation, however, the well has since been developed and sampled in 1994

Deviations from the Work Plan

- Monitoring wells 77392 and 76992 were installed about 300 feet east and 70 feet northeast from the easternmost borings in Trenches B and C, respectively instead of in the easternmost boring of Trench B and immediately north of Trench C, as specified in the Work Plan Based on a field reconnaissance prior to drilling the wells were placed in more favorable downgradient locations

2 2 7 North and South Spray Field Areas (IHSSs 167 1 and 167.3)

The North Spray Field Area (IHSS 167 1) is located on the ridge north of the Landfill Pond and is bounded on the northwest by the McKay Bypass Canal (Figure 1 3-3 page 1 of 2) Two drainages to the unnamed tributary of Walnut Creek mark the northeast and southeast boundaries of the IHSS The South Spray Field Area (IHSS 167 3) is situated on the ridge due south of the Landfill Pond, on the northwest corner of the intersection of the ridge access road and the Landfill Pond access road (Figure 1 3-3 page 1 of 2) The Pond Spray Field Area (IHSS 167 2) was included in the OU6 Phase I field investigations however, this IHSS was subsequently moved to OU7 for characterization and evaluation, and will be addressed in the OU7 RFI/RI Report Figure 1 3-3 page 1 of 2 shows the historical and revised boundaries for IHSS 167 2 Detailed descriptions of IHSSs 167 1 and 167 3 including waste-related activities are presented in Section 1 3 2 10

Investigation Stages 1 through 4 were conducted at IHSSs 167 1 and 167 3 A summary of the proposed and completed Phase I investigations at IHSSs 167 1 and 167 3 are presented on Table 2 2-1, and are discussed below

Stage 1 - Review Aerial Photographs

Aerial photographs from 1980 and 1983 were reviewed to evaluate locations of the spray fields The North Spray Field (IHSS 167 1) was not observed to be in use on any of the photographs The area in the vicinity of the South Spray Field (IHSS 167 3) was observed to have a round, darker-colored shape that may have been a center pivot sprinkler Sampling locations at IHSS 167 1 were based on the IHSS boundaries whereas the sampling locations at IHSS 167 3 were based on the spray field area visible on the photographs Soil and groundwater sampling locations for IHSSs 167 1 and 167 3 are shown on Figures 2 2-20 and 2 2-21 respectively

Stage 2 - Radiation Surveys

A 17-point FIDLER radiation survey was performed prior to sampling each surface soil and soil boring location as part of Stage 3 (discussed below), in accordance with EMRGs (EG&G 1991a) No anomalous radiation readings were detected during the FIDLER survey Results of the radiation survey are provided in Appendix B2

Stage 3 - Surface Soil, Soil Profile Pit, Soil Borings, Sediment and Surface Water Sampling

The Work Plan specified that surface soil samples were to be collected to a depth of 2 inches on a 100-foot grid over the areas of the spray fields as estimated from the aerial photo review conducted in Stage 1, in accordance to SOP GT 08. Soil borings were to be drilled to a depth of 4 feet on the same 100-foot grid, in accordance with SOP GT 02 Samples in the borings were to be taken continuously and composited from each 2-foot interval During sampling, a soil classification survey was to be completed at the Spray Fields for use in the Ecologic Risk Assessment

Surface soil samples were collected on a 100-foot grid spacing as specified in the Work Plan (Figures 2 2-20 and 2 2-21) A total of 23 and 8 surface soil samples were collected at IHSSs 167 1 and 167 3, respectively Surface soil samples were collected using the procedures discussed in Section 2 1 3 2

A total of 30 soil borings were drilled on the same 100-foot grid used for the surface soil sampling (Figures 2 2-20 and 2 2-21) Subsurface soil sampling procedures are discussed in Section 2 1 3 1 Borings were drilled to 4 feet Samples were taken continuously in the borings and were composited from each 2-foot interval for VOC analysis

Four soil samples were collected from a depth interval of 0 feet to 2 feet in several soil borings for grain size analysis The soil borings sampled for grain size analysis and the results of the analyses are discussed in Section 3 9 9 2 and presented on Table 3 5-3.

Additionally, a soil profile pit was excavated, described and sampled in the central portion of IHSS 167 3, as shown on Figure 2 2-21 Soil samples were collected in accordance with

SOP GT 07 Two stream sediment samples and one additional surface water sample specified in the Work Plan were omitted as defined in TM1

Surface and subsurface soil samples from IHSSs 167 1 and 167 3 were analyzed for the parameters listed in Tables 2 1-4 and 2 1-5 Analytical results of the sampling are presented in Appendixes D1 and D2 and are discussed in Sections 4 4 1 and 4 5 2

Deviations from the Work Plan

- One soil boring was not drilled at a surface soil site (SS600892) at IHSS 167 1, as specified in the Work Plan The steep terrain resulted in drill rig inaccessibility therefore the soil boring was omitted at this site

Stage 4 - Monitoring Wells

The Work Plan specified two monitoring wells were to be installed immediately downgradient of the North and South Spray Fields These wells were to be located within the surface drainages that flow toward North Walnut Creek If a water bearing sandstone unit was found to be the first bedrock unit underlying the alluvium an additional well was to be completed in the weathered sandstone unit at that location

Monitoring well 77192 was installed at the east end of the North Spray Field Area (IHSS 167 1) in the confluence of the unnamed tributaries north of North Walnut Creek (Figure 2 2-20) During the drilling of monitoring well 77192, colluvial material was encountered overlying the claystone bedrock Colluvial material lies within the same hydrostratigraphic unit as Rocky Flats Alluvium The colluvial/alluvial hydrostratigraphic relationship is discussed in detail in Section 3 6 2 of this report This well reached a total depth of 11 9 feet, and was screened in colluvium over a depth interval of 2 9 feet to 5 9 feet Monitoring well 76792 was drilled south of IHSS 167 3, in the drainage that flows toward the unnamed Tributary north of North Walnut Creek (Figure 2 2-21) The well reached a total depth of 12 2 feet and was screened in the Rocky Flats Alluvium over a depth interval of 3 5 feet to 5 8 feet No sandstone unit was encountered in the bedrock underlying the alluvium therefore no bedrock monitoring wells were drilled at either location Monitoring well installation procedures are discussed in Section 2 1 4 1 Well construction information is summarized on Table 2 1-8 and presented in Appendixes C2 10 and C2 12

As of the 4th quarter 1994, monitoring wells 77192 and 76792 remained dry and have not been developed

Deviations from the Work Plan

- No alluvial material was encountered in the drilling of monitoring well 77192, and the well was screened in colluvium instead of alluvium

- Soil boring 62892 (IHSS 167 1) encountered refusal at 3 8 feet and was unable to be drilled to 4 0 feet

- Soil boring 61592 was not drilled because the steep terrain prohibited drill rig access However, surficial soil sample number 600892 was collected at this location

- The two stream-sediment samples and the one additional surface water sample were omitted as specified in TM1

2 2 8 East Spray Field Area (IHSS 216 1)

The East Spray Field Area (IHSS 216 1) is located on the ridge between the North Walnut Creek and South Walnut Creek drainages, and is east of the Soil Dump Area (IHSS 156 2), as shown in Figure 1 3-3 (page 1 of 2) A detailed description of IHSS 216 1, including waste-related activities, is presented in Section 1 3 2 11

Investigation Stages 1 through 4 were conducted at IHSS 216 1 A summary of the proposed and completed Phase I investigations at IHSS 216 1 is presented on Table 2 2-1, and is discussed below

Stage 1 - Historical Data

Historical information regarding the use of the East Spray Field Area was included in the Work Plan and in the HRR (DOE 1992b)

Stage 2 - Radiation Survey

Prior to collection of surface and subsurface soil samples at IHSS 216 1 during Stage 3 (discussed below), a 17-point FIDLER radiation survey was conducted at each sampling location No anomalous radiation readings were detected in IHSS 216 1 during the FIDLER survey Results of the radiation survey are presented in Appendix B2

Stage 3 - Surface Soil Samples, Soil Profile Pit, and Soil Borings

Surface soil samples were collected on a 200-foot grid spacing over IHSS 216 1 (Figure 2 2-22) A total of six surface soil samples were collected to a depth of 2 inches

Additionally a soil profile pit was excavated described and sampled in the northwestern portion of IHSS 216 1 as shown on Figure 2 2-22 Soil samples were collected in accordance with SOP GT 07

A total of six soil borings were drilled on the same 200-foot grid used for the surface soil sampling (Figure 2 2-22) The soil borings were drilled to a depth of approximately four feet Samples were taken continuously in these soil borings and were composited from each 2-foot interval

Surface and subsurface soil samples form IHSS 216 1 were analyzed for the parameters listed in Tables 2 1-4 and 2 1-5 Analytical results of the sampling are presented in Appendixes D1 and D2 and are discussed in Section 4 4 3 2 and 4 5 4 2

Stage 4 - Monitoring Well

Since no contamination was detected during the field sampling it was not necessary to install an alluvial monitoring well within this IHSS

2.3 ECOLOGICAL RISK ASSESSMENT INVESTIGATION

Section 9 of the Work Plan, Ecological Risk Assessment was designed to describe the requirements for carrying out an ecological risk assessment (ERA) The initial field sampling plan (FSP) was intended for screening purposes and baseline site characterization The overall ERA Work Plan described an iterative approach with revisions planned after chemicals of concern, receptors and contaminant pathways were identified The Work Plan, Section 9, Ecological Risk Assessment was modified on two occasions, once in February 1993, and later in May 1994 in response to new findings The 1993 revised FSP was transmitted to the EPA and CDPHE by the DOE, but approval of the document was not requested and the regulatory agencies did not provide a formal review or approval The 1994 revision was created to respond to elevated levels of polychlorinated biphenyls in the OU6 pond sediment results

In October of 1994, the approach to ERAs for RFETS changed from an OU-based approach to a watershed approach for Woman Creek and Walnut Creek To accomplish this, a site-wide ERA methodology was drafted and approved by the regulatory agencies As a result, the scope of the Walnut Creek ERA expanded from OU6 and OU7 to include parts of OU2, OU4 outside of the Protected Area, and OU11 The modified field sampling plans for the OUs encompassed by the watershed ERAs are located in Appendix F and are not duplicated here

TABLE 2 1-1
SUMMARY OF OU6 PHASE I FIELD ACTIVITIES

IHSS NUMBER	ACTIVITY TYPE	QUANTITY
IHSS 141	Radiation Survey (17 point FIDLER)	40
Sludge Dispersal Area	Radiation Survey (HPGe)	1
	Surface Soil Sampling	40
	Monitoring Well (colluvial)	1
IHSSs 142 1 9 and 142 12	Pond Surface Water Sampling	51
A and B Series Ponds and	Pond Sediment Sampling	57
W&I Pond	Dry Sediment Sampling	18
	B 5 Monitoring Well (alluvial)	1
	A-4 Monitoring Well (bedrock)	1
Walnut Creek Drainage		11
	Stream Sediment Sampling (baseflow)	15
	Stream Surface Water Sampling (storm event)	8
IHSS 143	Radiation Survev (17 point FIDLER)	7
Old Outfall Area	Surface Soil Sampling	4
	Soil Boring	7
	Monitoring Well (alluvial)	1
	Soil Classification Survey (grain size sieve analysis)	1
IHSS 156 2	Radiation Survey (17 point FIDLER)	23
Soil Dump Area	Radiation Survey (HPGe)	1
	Surface Soil Sampling	22
	Soil Boring	22
	Monitoring Well (alluvial)	1
	Soil Classification Survey (grain size sieve analysis)	2
IHSS 165	Radiation Survey (17 point FIDLER)	32
Triangle Area	Radiation Survey (HPGe)	1
	Soil Boring	9
	Surface Soil Sampling	15
	Soil Gas Survey	31
	Soil Classification Survey (grain size sieve analysis)	1
	Soil Core Sampling	4
	Sediment Sampling	1
	Monitoring Well (alluvial)	1
	Monitoring Well (bedrock)	1
	Soil Profile Pit (60092)	1

TABLE 2 1-1
SUMMARY OF OU6 PHASE I FIELD ACTIVITIES

IHSS NUMBER	ACTIVITY TYPE	QUANTITY
IHSSs 166 1 through 166 3	Radiation Survey (17-point FIDLER)	28
Trenches A B & C	Geophysical EM Survey	1
	Soil Boring	26
	Soil Classification Survey (grain size sieve analysis)	3
	Monitoring Well (alluvial)	2
IHSSs 167 1 and 167 3	Radiation Survey (17-point FIDLER)	33
North Spray Field and	Surface Soil Sampling	31
South Spray Field Areas	Soil Boring	30
	Soil Classification Survey (grain size sieve analysis)	4
	Monitoring Well (alluvial)	1
	Monitoring Well (colluvial)	1
	Soil Profile Pit (60192)	1
IHSS 216 1	Radiation Survey (17-point FIDLER)	6
East Spray Field Area	Soil Boring	6
	Soil Profile Pit (60292)	1

TABLE 2 1-2
SUMMARY OF STANDARD OPERATING PROCEDURES USED IN THE OU-6 RFI/RI FIELD INVESTIGATION

SOP NUMBER	TITLE
FO 01	Air Monitoring and Dust Control
FO 02	Field Document Control
FO 03	General Equipment Decontamination
FO 04	Heavy Equipment Decontamination
FO 06	Handling of Personal Protective Equipment
FO 07	Handling of Decontamination Water and Wash Water
FO 08	Handling of Drilling Fluids and Cuttings
FO 09	Handling of Residual Samples
FO 10	Receiving Labeling and Handling Environmental Material Containers
FO 11	Field Communications
FO 12	Decontamination Facility Operations
FO 13	Containerization Preserving Handling and Shipping of Soil and Water Samples
FO 14	Field Data Management
FO 15	Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs)
FO 16	Field Radiological Measurement FIDLER surveys
FO 18	Environmental Sample Radioactivity Content Screening
GT 01	Logging Alluvial and Bedrock Material
GT 02	Drilling and Sampling Using Hollow Stem Auger Techniques
GT 05	Plugging and Abandonment of Boreholes
GT 06	Monitoring Wells and Piezometers Installation
GT 07	Logging and Sampling of Test Pits and Trenches
GT 08	Surface Soil Sampling
GT 09	Soil Gas Sampling and Field Analysis
GT 10	Borehole Clearing
GT 11	Plugging and Abandonment of Wells
GT 17	Land Surveying
GW 02	Well Development
GW 04	Slug Testing

TABLE 2 1-2
SUMMARY OF STANDARD OPERATING PROCEDURES USED IN THE OU-6 RFI/RI FIELD INVESTIGATION

SOP NUMBER	TITLE
GW 06	Well Samplıng
SW 01	Surface Water Data Collectıon Actıvıtıes
SW 02	Fıeld Measurements of Surface Water Fıeld Parameters
SW 03	Surface Water Samplıng
SW 04	Dıscharge Measurement
SW 06	Sedıment Samplıng
SW 08	Pond Samplıng

TABLE 2 1-3
LIST OF DCNs TO THE OU-6 RFI/RI WORK PLAN AND TM1 IMPLEMENTED IN PERFORMING THE PHASE I FIELD WORK

Work Plan Section No	Title	Date
Section 2 0	SITE CHARACTERIZATION	
DCN 92 01	Replacement of tables with correct tables	6/1/92
DCN 93 01	Site characterization	1/29/93
Section 7 0	FIELD SAMPLING PLAN	
DCN 93 01	Change to 7 2 5	1/18/93
DCN 93 02	IHSS Map Figure 7 5, Table 7-1	1/29/93
DCN 93 03	Revision to 7 2 3	2/5/93
DCN 93 04	Change to sentence 7 2.5, stage 4	8/30/93
Section 10 0	QUALITY ASSURANCE ADDENDUM	
DCN 92 01	Change in QC Frequency	10/5/92
DCN 93 01	Modification to agree with Section 7 0	2/21/93
DCN 93 01	Replacement of first two sentences page 12 3 2 1	2/21/93
	TABLE 2 FIELD QC SAMPLE COLLECTION FREQUENCY	
DCN 92 01	Change on page 17 of 41 Table 2 (Field Blank and Trip Blank)	10/5/92
Appendices	TECHNICAL MEMORANDUM #1	
DCN 93 01	Appendix H 5 0 paragraph 1	8/30/93
OPS SW2		
DCN 93 01	page 12 5 6 (Alkalinity/pH measurements)	5/11/93

Work Plan Reference - DOE 1992a
TM1 Reference DOE 1992f

TABLE 2 1 5
OU6 PHASE I RFI/RI ANALYTICAL PARAMETERS

TARGET ANALYTE LIST (TAL) METALS
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Cyanide
- Iron Total and Dissolved
- Lead
- Magnesium
- Manganese Total and Dissolved
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Vanadium
- Zinc

ADDITIONAL METALS
- Cesium
- Lithium
- Molybdenum
- Silicon
- Strontium
- Tin

GRAPHITE FURNACE ATOMIC ABSORPTION (GFAA) METALS
- Cadmium
- Copper
- Iron Total
- Lead
- Manganese
- Silver
- Zinc

TARGET COMPOUND LIST (TCL) VOCs
- Chloromethane
- Bromomethane
- Vinyl chloride
- Chloroethane
- Methylene chloride
- Acetone
- Carbon disulfide
- 1,1 Dichloroethene
- 1 1 Dichloroethane
- total 1 2 Dichloroethene
- Chloroform
- 1,2 Dichloroethane
- 2 Butanone
- 1 1 1-Trichloroethane
- Carbon tetrachloride
- Vinyl acetate
- Bromodichloromethane
- 1 1 2 2-Tetrachloroethane
- 1 2 Dichloropropane
- cis 1 3 Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1 1 2 Trichloroethane
- Benzene
- trans 1 3 Dichloropropene
- Bromoform
- 2 Hexanone
- 4 Methyl 2 pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl benzene
- Styrene
- Total xylenes

TCL SVOCs
- Phenol
- bis(2 Chloroethyl)ether
- 2 Chlorophenol
- 1 3 Dichlorobenzene
- 1 4 Dichlorobenzene
- Benzyl alcohol

TABLE 2 1-5
OU6 PHASE I RFI/RI ANALYTICAL PARAMETERS

TCL SVOCs
- 1 2-Dichlorobenzene
- 2-Methylphenol
- bis(2-Chloroisopropyl)ether
- 4-Methylphenol
- N-Nitroso-di-n-dipropylamine
- Hexachloroethane
- Nitrobenzene
- Isophorone
- 2 Nitrophenol
- 2 4-Dimethylphenol
- Benzoic acid
- bis(2-Chloroethoxy)methane
- 2 4-Dichlorophenol
- 1,2 4 Trichlorobenzene
- Naphthalene
- 4-Chloroaniline
- Hexachlorobutadiene
- 4-Chloro 3-methylphenol (para-chloro-meta-cresol)
- 2-Methylnaphthalene
- Hexachlorocyclopentadiene
- 2 4 6-Trichlorophenol
- 2 4 5-Trichlorophenol
- 2-Chloronaphthalene
- 2 Nitroaniline
- Dimethylphthalate
- Acenaphthylene
- 2 6-Dinitrotoluene
- 3 Nitroaniline
- Acenaphthene
- 2 4 Dinitrophenol
- 4 Nitrophenol
- Dibenzofuran
- 2 4-Dinitrotoluene
- Diethylphthalate
- 4 Chlorophenyl phenyl ether
- Fluorene
- 4 Nitroaniline
- 4 6 Dinitro 2-methylphenol
- N Nitrosodiphenylamine
- 4 Bromophenyl phenyl ether
- Hexachlorobenzene
- Pentachlorophenol
- Phenanthrene
- Anthracene
- Di n butylphthalate

TCL-SVOCs
- Fluoranthene
- Pyrene
- Butylbenzylphthalate
- 3,3 -Dichlorobenzidine
- Benzo(a)anthracene
- Chrysene
- bis(2-Ethylhexyl)phthalate
- Di-n-octylphthalate
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Indeno(1,2,3-cd)pyrene
- Dibenz(a,h)anthracene
- Benzo(g,h,i)perylene

TCL - PESTICIDES/PCBs
- alpha-BHC
- beta BHC
- delta-BHC
- gamma-BHC (Lindane)
- Heptachlor
- Aldrin
- Heptachlor epoxide
- Endosulfan I
- Dieldrin
- 4 4-DDE
- Endrin
- Endosulfan II
- 4 4 DDD
- Endosulfan sulfate
- 4 4 DDT
- Methoxychlor
- Endrin ketone
- alpha Chlordane
- gamma Chlordane
- Toxaphene
- Aroclor 1016
- Aroclor 1221
- Aroclor 1232
- Aroclor 1242
- Aroclor 1248
- Aroclor 1254
- Aroclor 1260

TABLE 2 1-5
OU6 PHASE I RFI/RI ANALYTICAL PARAMETERS

RADIONUCLIDES
- Gross Alpha
- Gross Beta
- Uranium 233+234 235 and 238 (each species)
- Americium 241
- Plutonium 239/240
- Tritium
- Cesium 137 Total
- Strontium 89 + 90 Total

TOTAL ORGANIC CARBON (TOC)
NITRATE/NITRITE AS N

Parameters Exclusively for Groundwater Samples

FIELD PARAMETERS
- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen
- Barometric Pressure

WATER QUALITY PARAMETER LIST (WQPL)
- Chloride
- Fluoride
- Sulfate
- Carbonate
- Bicarbonate
- Total Dissolved Solids
- Total Suspended Solids

ADDITIONAL PARAMETERS FOR IHSS
142 1 9 AND 142 12 WATER SAMPLES
- DOC
- Silicon
- Alkalinity

TABLE 2 1-6
SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES (SURFACE WATER AND GROUNDWATER)

Parameter	Container	Preservative	Holding Time
Organic Chemicals			
VOCs	2 x 40 ml VOC vials with teflon lined septum lids	Cool 4°C	14 days
Extractable Organics (SVOCs Pesticides/ PCBs)	3 x 1 L amber[2] glass bottle	Cool, 4°C	7 days until extraction 40 days after extraction
Inorganic Chemicals			
Metals	1 x 1-L polyethylene bottle	Nitric acid pH<2 Cool 4°C	180 days[1]
Cyanide	1 x 1-L polyethylene bottle	Sodium hydroxide pH>12 Cool 4°C	14 days
WQPL	1 x 1-L polyethylene bottle	Cool 4°C	14 days
Nitrate and Nitrite	1 x 500 ml polyethylene bottle	Sulfuric acid to pH 2 Cool 4°C	28 days
NH_4+ as NH_3	1 x 1 L polyethylene bottle	Sulfuric pH<2	28 days
Hardness	1 x 250 ml amber glass bottle	Sulfuric pH<2	6 months
Total Organic Carbon (TOC)	1 x 250-ml amber glass	Sulfuric acid to pH<2 Cool 4°C	28 days
Radionuclides			
Radionuclides (Full Suite)	12 x 1 L polyethylene bottle	Cool 4°C	180 days
Tritium	1 x 250 ml amber glass	Cool 4°C	180 days
Additional Parameters			
Acute Toxicity	2 x 1 gal polyethylene bottle	Cool 4°C	36 hours
Microtox	1 x 40 ml glass vial	Cool 4°C	36 hours

[1] Holding time for mercury is 28 days
[2] Container requirement is for any or all of the parameters given

TABLE 2 1-6
SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES (SOIL AND SEDIMENT SAMPLES)

Parameter	Container	Preservative	Holding Time
Organic Chemicals			
VOCs	1 x 8-oz split-spoon liner with teflon lined caps	Cool, 4° C	14 days
Extractable Organics (SVOCs, Pesticides/ PCBs)	1 x 8-oz wide-mouth glass	Cool, 4° C	7 days until extraction, 40 days after extraction
Inorganic Chemicals			
Metals	1 x 250-ml wide-mouth glass jar	Cool 4° C	180 days[1]
TOC[3]			28 days
Nitrate[3]			48 hours
Radionuclides	1 x 500-ml wide-mouth glass jar	None	45 days

[1] Holding time for mercury is 28 days
[3] When TOC or Nitrate were requested at a given IHSS one sample was taken and included with metals

TABLE 2 1-7
QUALITY CONTROL SAMPLES AND COLLECTION/ANALYSIS FREQUENCY

Sample Type	Analyte Type	Collection/Analysis Frequency	
		Solids	Liquids
Duplicates	Organics	1 in 10	1 in 10
	Inorganics	1 in 10	1 in 10
	Radionuclides	1 in 10	1 in 10
Equipment Blanks	Organics	1per day or 1 in 20	1 in 20
	Inorganics	1 in 20	1 in 20
	Radionuclides	1 in 20	1 in 20
Trip Blanks	Organics	NA	1 in 20
	Inorganics	NA	NA
	Radionuclides	NA	NA
Matrix Spike/Matrix Spike Duplicate	Organics	1 in 20	1 in 20
	Inorganics	1 in 20	1 in 20
Lab Replicate	Radionuclides	1 in 20	1 in 20

NA = Not Analyzed

TABLE 2.1-8
OU6 PHASE I MONITORING WELL INSTALLATION INFORMATION

Site Number	State Plane Coordinates Easting	State Plane Coordinates Northing	IHSS Location	Well Type	Ground Surface Elevation ft (AMSL)	Well Casing Stickup ft (AGS)	Top of Well Casing Elevation ft (AMSL)	Depth of Screened Interval ft (BGS)	Elevation of Screened Interval ft (AMSL)	Stratigraphy of Screened Interval	Depth to top of Bedrock ft (BGS)	Elevation of top of Bedrock ft (AMSL)	Total Casing Depth ft (BGS)	Boring Total Depth ft (BGS)
75092	2089870	753228	142 4	Bedrock	5723 40	1 9	5725 30	7 2 14 7	5716 2 5708 7	Kl	6 3	5717 10	14 7	16 7
75292	2089809	752305	142 9	Alluvuial	5754 90	2 0	5756 90	5 6-7 6	5749 3-5747 3	Qrf	7 6	5747 30	7 6	13 6
75892	2086558	750915	156 2	Alluvial	5956 20	3 0	5959 20	4 3 7 3	5951 9-5948 9	Qvf	7 6	5948 60	7.3	14 6
75992	2086628	750290	141	Colluvial	5897 10	2.0	5899 10	5 0-10 0	5892.1 5887 1	Qc	10 0	5887 10	10.0	15 5
76192	2086122	750660	165	Alluvial	5960 00	3 0	5963 00	4.0-6 0	5956 0-5954 0	Qrf	6.0	5954 00	6 0	14 0
76292	2085681	750769	165	Bedrock	5957 00	2 3	5959 30	9 2 19 2	5947 8-5937 8	Ka	8 5	5948 50	19 2	21 2
76792	2084618	752546	167 3	Alluvial	5943.50	2 0	5945 50	3 5-5 8	5940 0-5938 0	Qrf	6 3	5937 20	5 8	12 2
76992	2084500	752561	166 3	Alluvial	5955 00	3 0	5958 00	3 4-9 4	5951 6-5945 6	Qrf	9 6	5945 40	9 4	15 5
77192	2084381	753646	167 1	Colluvial	5913 90	3 2	5917 10	2.9-5 9	5911 0-5908 0	Qc	NE	NE	5 9	11 9
77392	2084299	752243	166 2	Alluvial	5962.50	2.0	5964 50	3.0-6 9	5958 6-5955 6	Qrf	7 0	5955 50	6 9	13 8
77492	2083508	751246	143	Alluvial	5942.00	2.5	5944.50	12.1 22.1	5929 9-5919.9	Qrf	22 5	5919 50	22 1	24 1

Explanation

IHSS- Individual Hazardous Substance Site
AGS- Above Ground Surface
BGS- Below Ground Surface
AMSL- Above Mean Sea Level
NE- not encountered
Qrf Quaternary Rocky Flats Alluvium
Qc Quaternary colluvium
Qvf Quaternary Valley-Fill Alluvium
Ka- Cretaceous Arapahoe Formation
Kl- Cretaceous Laramie Formation

TABLE 2 1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 141 (Sludge Dispersal Area)			
SS609792	2086390	750302	Surface Soil
SS609892	2086390	750276	Surface Soil
SS609992	2086391	750251	Surface Soil
SS610492	2086414	750302	Surface Soil
SS610592	2086414	750277	Surface Soil
SS610692	2086415	750252	Surface Soil
SS611192	2086440	750303	Surface Soil
SS611292	2086440	750278	Surface Soil
SS611392	2086440	750252	Surface Soil
SS612092	2086506	750429	Surface Soil
SS612192	2086507	750404	Surface Soil
SS612892	2086524	750430	Surface Soil
SS612992	2086525	750404	Surface Soil
SS613092	2086527	750379	Surface Soil
SS613192	2086527	750353	Surface Soil
SS613292	2086527	750328	Surface Soil
SS613392	2086527	750303	Surface Soil
SS613492	2086528	750278	Surface Soil
SS613592	2086528	750253	Surface Soil
SS613692	2086550	750430	Surface Soil
SS613792	2086575	750430	Surface Soil
SS613892	2086574	750405	Surface Soil
SS613992	2086575	750380	Surface Soil
SS614092	2086574	750355	Surface Soil
SS614192	2086575	750329	Surface Soil
SS614292	2086574	750304	Surface Soil
SS614392	2086574	750279	Surface Soil
SS614492	2086575	750254	Surface Soil
SS614592	2086600	750430	Surface Soil
SS614692	2086600	750405	Surface Soil
SS614792	2086600	750379	Surface Soil
SS614892	2086600	750355	Surface Soil
SS614992	2086600	750330	Surface Soil
SS615092	2086600	750304	Surface Soil
SS615192	2086600	750279	Surface Soil
SS615292	2086600	750253	Surface Soil
SS620792	2086363	750458	Surface Soil
SS620892	2086388	750457	Surface Soil
SS620992	2086413	750458	Surface Soil
SS621092	2086434	750458	Surface Soil
75992	2086628	750290	Monitoring Well

TABLE 2.1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 142 1 (Pond A 1)			
SED60092	2086553	752020	Pond Sediment
SED60192	2086270	751966	Pond Sediment
SED60292	2086426	751947	Pond Sediment
SED60392	2086505	752010	Pond Sediment
SED60492	2086292	751931	Pond Sediment
SED65092	2086164	751861	Dry Sediment
SED65192	2086258	751888	Dry Sediment
SW60092	2086553	752020	Surface Water-Pond
SW60192	2086270	751966	Surface Water-Pond
SW60292	2086587	751980	Surface Water-Pond
SW60392	2086505	752010	Surface Water Pond
SW60492	2086292	751931	Surface Water-Pond
IHSS 142.2 (Pond A-2)			
SED60592	2086993	752094	Pond Sediment
SED60692	2087179	752087	Pond Sediment
SED60792	2087253	752165	Pond Sediment
SED60892	2087310	752174	Pond Sediment
SED60992	2086964	752116	Pond Sediment
SED65292	2086751	751994	Dry Sediment
SED65392	2086909	752121	Dry Sediment
SW60592	2086993	752094	Surface Water-Pond
SW60692	2087179	752087	Surface Water-Pond
SW60792	2087387	752118	Surface Water-Pond
SW60892	2087310	752174	Surface Water-Pond
SW60992	2086686	751961	Surface Water-Pond
IHSS 142.3 (Pond A-3)			
SED61092	2088256	752395	Pond Sediment
SED61192	2088168	752356	Pond Sediment
SED61292	2087986	752260	Pond Sediment
SED61392	2088323	752536	Pond Sediment
SED61492	2087818	752311	Pond Sediment
SED65492	2087711	752246	Dry Sediment
SED65592	2087782	752246	Dry Sediment
SW61092	2088256	752395	Surface Water-Pond
SW61192	2088168	752356	Surface Water-Pond
SW61292	2088431	752397	Surface Water-Pond
SW61392	2088323	752536	Surface Water-Pond
SW61492	2087700	752172	Surface Water-Pond

TABLE 2 1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 142 4 (Pond A 4)			
SED61592	2089497	752865	Pond Sediment
SED61692	2089723	752971	Pond Sediment
SED61792	2089448	752924	Pond Sediment
SED61892	2089674	753022	Pond Sediment
SED61992	2089294	7526953	Pond Sediment
SED65692	2088529	752609	Dry Sediment
SED65792	2088819	752664	Dry Sediment
SW61592	2089497	752865	Surface Water Pond
SW61692	2089723	752971	Surface Water Pond
SW61792	2089678	753084	Surface Water Pond
SW61892	2089674	753022	Surface Water Pond
SW61992	2089294	752953	Surface Water Pond
75092	2089870	753228	Monitoring Well
IHSS 142.5 (Pond B 1)			
SED62092	2087052	750536	Pond Sediment
SED62192	2087119	750520	Pond Sediment
SED62292	2087102	750523	Pond Sediment
SED62392	2087083	750556	Pond Sediment
SED62492	2086983	750455	Pond Sediment
SED65892	2086774	750318	Dry Sediment
SED65992	2086652	750321	Dry Sediment
SW62092	2087052	750536	Surface Water Pond
SW62192	2087119	750520	Surface Water Pond
SW62292	2087106	750556	Surface Water Pond
SW62392	2087083	750556	Surface Water Pond
SW62492	2086983	750455	Surface Water-Pond
IHSS 142 6 (Pond B 2)			
SED62592	2087378	750642	Pond Sediment
SED62692	2087281	750604	Pond Sediment
SED62792	2087495	750623	Pond Sediment
SED62892	2087456	750609	Pond Sediment
SED62992	2087217	750618	Pond Sediment
SED66092	2087182	750653	Dry Sediment
SED66192	2087197	750681	Dry Sediment
SW62592	2087378	750642	Surface Water Pond
SW62692	2087281	750604	Surface Water Pond
SW62792	2087499	750699	Surface Water Pond
SW62892	2087456	750609	Surface Water Pond
SW62992	2087217	750618	Surface Water Pond

TABLE 2 1-9

OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 142 7 (Pond B-3)			
SED63092	2087848	750765	Pond Sediment
SED63192	2087815	750837	Pond Sediment
SED63292	2087796	750757	Pond Sediment
SED63392	2087793	750792	Pond Sediment
SED63492	2087698	750786	Pond Sediment
SED66292	2087623	750744	Dry Sediment
SED66392	2087651	750778	Dry Sediment
SW63092	2087848	750765	Surface Water-Pond
SW63192	2087815	750837	Surface Water-Pond
SW63292	2087796	750757	Surface Water-Pond
SW63392	2087793	750792	Surface Water-Pond
SW63492	2087698	750786	Surface Water-Pond
IHSS 142.8 (Pond B-4)			
SED63592	2088169	750869	Pond Sediment
SED63692	2088194	750329	Pond Sediment
SED63792	2088256	750872	Pond Sediment
SED63892	2088233	750898	Pond Sediment
SED63992	2088119	750912	Pond Sediment
SED66492	2087932	750802	Dry Sediment
SED66592	2088030	750871	Dry Sediment
SW63592	2088148	750906	Surface Water-Pond
SW63692	2088194	750929	Surface Water-Pond
SW63792	2088251	750960	Surface Water-Pond
SW63892	2088223	750898	Surface Water-Pond
SW63992	2088119	750912	Surface Water-Pond
IHSS 142.9 (Pond B-5)			
SED64092	2089080	751734	Pond Sediment
SED64192	2089540	751924	Pond Sediment
SED64292	2089466	752081	Pond Sediment
SED64392	2089521	751994	Pond Sediment
SED64492	2088990	751706	Pond Sediment
SED66692	2088356	750990	Dry Sediment
SED66792	2088612	751309	Dry Sediment
SW64092	2089080	751734	Surface Water Pond
SW64192	2089540	751924	Surface Water-Pond
SW64292	2089466	752081	Surface Water-Pond
SW64392	2089521	751994	Surface Water-Pond
SW64492	2088990	751706	Surface Water-Pond
75292	2089809	752305	Monitoring Well

TABLE 2 1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 142 12 (W&I Pond)			
SED64592	2093510	753694	Pond Sediment
SED64692	2093554	753636	Pond Sediment
SED64792	2093513	753756	Pond Sediment
SED64892	2093563	753684	Pond Sediment
SED64992	2093452	753746	Pond Sediment
SW64592	2093580	753726	Surface Water Pond
SW64692	2093554	753636	Surface Water-Pond
SW64792	2093603	753665	Surface Water-Pond
SW64892	2093563	753684	Surface Water Pond
SW64992	2093452	753746	Surface Water Pond
IHSS 143 (Old Outfall Area)			
60092	2083494	751231	Soil Boring
60192	2083520	751228	Soil Boring
60292	2083496	751241	Soil Boring
60392	2083508	751237	Soil Boring
60492	2083496	751246	Soil Boring
60692	2083307	750924	Soil Boring
SS600092	2083494	751231	Surface Soil
SS600192	2083520	751228	Surface Soil
SS600292	2083496	751241	Surface Soil
SS600392	2083508	751237	Surface Soil
77492 (60592)	2083508	751246	Monitoring Well (Soil Boring)
IHSS 156 2 (Soil Dump Area)			
63592	2086336	750971	Soil Boring
63692	2086252	751032	Soil Boring
73592	2086447	751004	Soil Boring
73692	2086514	750889	Soil Boring
73792	2086591	750761	Soil Boring
73892	2086588	751059	Soil Boring
73992	2086658	750935	Soil Boring
74092	2086734	750803	Soil Boring
74192	2086671	751026	Soil Boring
74292	2086716	751116	Soil Boring
74392	2086798	750991	Soil Boring
74492	2086872	750860	Soil Boring
74592	2086832	751088	Soil Boring
74692	2086910	750960	Soil Boring
74792	2086861	751175	Soil Boring
74892	2086925	751062	Soil Boring
74992	2086952	751152	Soil Boring

TABLE 2 1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 156.2 (Soil Dump Area) (continued)			
77592	2087016	751049	Soil Boring
77692	2087055	751148	Soil Boring
77792	2087076	751255	Soil Boring
77892	2087132	751155	Soil Boring
77992	2087177	751233	Soil Boring
SS602892	2086336	750971	Surface Soil
SS602992	2086252	751032	Surface Soil
SS606792	2086447	751004	Surface Soil
SS606892	2086514	750889	Surface Soil
SS606992	2086591	750761	Surface Soil
SS607092	2086588	751059	Surface Soil
SS607192	2086658	750935	Surface Soil
SS607292	2086734	750803	Surface Soil
SS607392	2086671	751026	Surface Soil
SS607492	2086716	751116	Surface Soil
SS607592	2086798	750991	Surface Soil
SS607692	2086872	750860	Surface Soil
SS607792	2086832	751088	Surface Soil
SS607892	2086910	750960	Surface Soil
SS607992	2086861	751175	Surface Soil
SS608092	2086925	751062	Surface Soil
SS608192	2086952	751152	Surface Soil
SS608292	2087016	751049	Surface Soil
SS608392	2087055	751148	Surface Soil
SS608492	2087076	751255	Surface Soil
SS608592	2087132	751155	Surface Soil
SS608692	2087177	751233	Surface Soil
75892	2086558	750915	Monitoring Well
IHSS 165 (Triangle Area)			
63792	2085864	750530	Soil Gas Survey
63892	2085858	750631	Soil Gas Survey
63992	2085856	750738	Soil Gas Survey
69492	2086169	750699	Soil Gas Survey
69592	2086084	750685	Soil Gas Survey
69692	2086089	750613	Soil Gas Survey
69792	2085990	750766	Soil Gas Survey
69892	2085989	750684	Soil Gas Survey
69992	2085987	750608	Soil Gas Survey
70092	2085987	750538	Soil Gas Survey
70192	2085420	750421	Soil Gas Survey
70292	2085417	750523	Soil Gas Survey

TABLE 2 1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 165 (Triangle Area) (continued)			
70392	2085417	750620	Soil Gas Survey
70492	2085419	750721	Soil Gas Survey
70592	2085415	750839	Soil Gas Survey
70692	2085416	750943	Soil Gas Survey
70792	2085508	750720	Soil Gas Survey
70892	2085530	750625	Soil Gas Survey
70992	2085541	750523	Soil Gas Survey
71092	2085531	750418	Soil Gas Survey
71192	2085651	750432	Soil Gas Survey
71292	2085640	750520	Soil Gas Survey
71392	2085642	750621	Soil Gas Survey
71492	2085681	750769	Soil Gas Survey
71592	2085645	750838	Soil Gas Survey
71692	2085642	750934	Soil Gas Survey
71792	2085758	750840	Soil Gas Survey
71892	2085764	750733	Soil Gas Survey
71992	2085766	750627	Soil Gas Survey
72092	2085772	750540	Soil Gas Survey
72192	2085770	750475	Soil Gas Survey
72292	2085416	750421	Soil Boring
72392	2085651	750432	Soil Boring
72492	2085770	750475	Soil Core
72592	2085417	750523	Soil Core
72692	2085541	750523	Soil Core
72792	2085640	750520	Soil Boring
72892	2085772	750540	Soil Boring
72992	2085530	750625	Soil Boring
73092	2085508	750720	Soil Boring
73292	2085764	750733	Soil Core
73392	2085856	750738	Soil Boring
73492	2085758	750840	Soil Boring
SS620592	2085864	750530	Surface Soil
SS606192	2086169	750699	Surface Soil
SS620192	2086084	750685	Surface Soil
SS606292	2085987	750608	Surface Soil
SS620292	2085987	750538	Surface Soil
SS603092	2085417	750523	Surface Soil
SS620392	2085416	750943	Surface Soil
SS603192	2085508	750720	Surface Soil
SS603292	2085530	750625	Surface Soil
SS620092	2085531	750418	Surface Soil
SS606392	2085651	750432	Surface Soil

TABLE 2.1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 165 (Triangle Area) (continued)			
SS606492	2085640	750520	Surface Soil
SS606592	2085645	750838	Surface Soil
SS606692	2085764	750733	Surface Soil
SS620492	2085766	750627	Surface Soil
76192	2086122	750660	Monitoring Well
76292/73192	2085681	750769	Monitoring Well/Soil Boring
TR60092	2086098	750658	Soil Profile Pit
IHSS 166 1 (Trench A)			
66892	2083922	752425	Soil Boring
66992	2083945	752429	Soil Boring
67092	2083971	752434	Soil Boring
67192	2083998	752439	Soil Boring
67292	2084020	752443	Soil Boring
67392	2084046	752448	Soil Boring
67492	2084068	752451	Soil Boring
68292	2083903	752403	Soil Boring
IHSS 166.2 (Trench B)			
67592	2083853	752201	Soil Boring
67692	2083876	752207	Soil Boring
67792	2083904	752212	Soil Boring
67892	2083928	752216	Soil Boring
67992	2083953	752220	Soil Boring
68092	2083979	752225	Soil Boring
68192	2084001	752228	Soil Boring
77392	2084299	752243	Monitoring Well
IHSS 166.3 (Trench C)			
68392	2083872	752302	Soil Boring
68492	2083898	752308	Soil Boring
68592	2083924	752315	Soil Boring
68692	2083946	752319	Soil Boring
68792	2083973	752324	Soil Boring
68892	2083999	752327	Soil Boring
68992	2084328	752532	Soil Boring
69092	2084352	752533	Soil Boring
69192	2084380	752536	Soil Boring
69292	2084402	752537	Soil Boring
69392	2084427	752540	Soil Boring
76992	2084500	752561	Monitoring Well

TABLE 2 1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 167 1 (North Spray Field)			
61192	2083890	753838	Soil Boring
61292	2083779	753780	Soil Boring
61392	2083892	753784	Soil Boring
61492	2083996	753789	Soil Boring
61692	2083891	753681	Soil Boring
61792	2083996	753678	Soil Boring
61892	2084116	753666	Soil Boring
61992	2084192	753653	Soil Boring
62092	2084280	753636	Soil Boring
62192	2083782	753577	Soil Boring
62292	2083593	753691	Soil Boring
62392	2083671	753690	Soil Boring
62492	2083781	753686	Soil Boring
62592	2083892	753574	Soil Boring
62692	2083997	753568	Soil Boring
62792	2084103	753564	Soil Boring
62892	2084201	753565	Soil Boring
62992	2083890	753519	Soil Boring
63092	2083673	753626	Soil Boring
63192	2083776	753626	Soil Boring
63292	2084098	753519	Soil Boring
63392	2083998	753464	Soil Boring
SS600492	2083890	753838	Surface Soil
SS600592	2083779	753780	Surface Soil
SS600692	2083892	753784	Surface Soil
SS600792	2083996	753789	Surface Soil
SS600892	2084103	753777	Surface Soil
SS600992	2083891	753681	Surface Soil
SS601092	2083996	753678	Surface Soil
SS601192	2084116	753666	Surface Soil
SS601292	2084192	753653	Surface Soil
SS601392	2084280	753636	Surface Soil
SS601492	2083782	753577	Surface Soil
SS601592	2083593	753691	Surface Soil
SS601692	2083671	753690	Surface Soil
SS601792	2083781	753686	Surface Soil
SS601892	2083892	753574	Surface Soil
SS601992	2083997	753568	Surface Soil
SS602092	2084103	753564	Surface Soil
SS602192	2084201	753565	Surface Soil
SS602292	2083890	753519	Surface Soil
SS602392	2083673	753626	Surface Soil

TABLE 2.1-9
OU6 PHASE I RFI/RI SITE NUMBERS AND SURVEY COORDINATES

SITE NUMBERS	SITE LOCATION State Easting	State Northing	SITE TYPES
IHSS 167.1 (North Spray Field) (continued)			
SS602492	2083776	753626	Surface Soil
SS602592	2084098	753519	Surface Soil
SS602692	2083998	753464	Surface Soil
77192	2084381	753646	Monitoring Well
IHSS 167.3 (South Spray Field)			
66092	2084470	752482	Soil Boring
66192	2084618	752455	Soil Boring
66292	2084538	752409	Soil Boring
66392	2084671	752434	Soil Boring
66492	2084467	752364	Soil Boring
66592	2084603	752366	Soil Boring
66692	2084536	752323	Soil Boring
66792	2084674	752333	Soil Boring
SS605392	2084470	752482	Surface Soil
SS605492	2084618	752455	Surface Soil
SS605592	2084538	752409	Surface Soil
SS605692	2084671	752434	Surface Soil
SS605792	2084467	752364	Surface Soil
SS605892	2084603	752366	Surface Soil
SS605992	2084536	752323	Surface Soil
SS606092	2084674	752333	Surface Soil
76792	2084618	752546	Monitoring Well
TR60192	2084570	752377	Soil Profile Pit
IHSS 216.1 (East Spray Field Area)			
SS608792	2087565	751384	Surface Soil
SS608892	2087768	751238	Surface Soil
SS608992	2087756	751444	Surface Soil
SS609092	2087573	751187	Surface Soil
SS609192	2087970	751472	Surface Soil
SS609292	2087963	751287	Surface Soil
78092	2087565	751384	Soil Boring
78192	2087768	751238	Soil Boring
78292	2087756	751444	Soil Boring
78392	2087573	751187	Soil Boring
78492	2087970	751472	Soil Boring
78592	2087963	751287	Soil Boring
TR60292	2087681	751432	Soil Profile Pit

TABLE 2 10
OU6 PHASE I STREAM SURFACE WATER (BASEFLOW/STORM EVENT) AND SEDIMENT SAMPLE SURVEY COORDINATES

ORIGINAL STATION ID	SITE NUMBERS	SITE LOCATION State Easting	State Northing	SAMPLE TYPES
Stream Sediment Sampling				
SW116	SED69492	2081072	750875	Stream Sediment
SW118	SED69692	2083514	751533	Stream Sediment
SW093	SED68592	2085005	751722	Stream Sediment
GS13	SED68492	2086091	751876	Stream Sediment
SW091B	SED68192	2086301	751610	Stream Sediment
GS12	SED68692	2088575	752632	Stream Sediment
GS11	SED68792	2089964	753270	Stream Sediment
GS03	SED69392	2093618	753646	Stream Sediment
GS09	SED69792	2088380	751055	Stream Sediment
GS10	SED69892	2086289	750227	Stream Sediment
SW103	SED69992	2088786	750848	Stream Sediment
SW022	SED70092	2086438	749759	Stream Sediment
#1	SED68992	2090219	753616	Stream Sediment
#2	SED69292	2091343	754080	Stream Sediment
#3	SED68892	2090269	753441	Stream Sediment
Baseflow Surface Water Sampling				
SW116	SW67093	2081072	750875	Surface water baseflow
SW118	SW67493	2083514	751533	Surface water baseflow
SW093	SW67193	2085005	751722	Surface water baseflow
GS13	SW67393	2086091	751876	Surface water baseflow
SW091B	SW68193	2086301	751610	Surface water baseflow
GS12	SW68093	2088575	752632	Surface water baseflow
GS11	SW67893	2089964	753270	Surface water baseflow
GS03	SW67993	2093618	753646	Surface water baseflow
GS09	SW67693	2088380	751055	Surface water baseflow
GS10	SW67593	2086289	750227	Surface water baseflow
#2	SW68293	2091343	754080	Surface water baseflow
Storm Event Surface Water Sampling				
SW116	SW68593	2081072	750875	Surface water storm event
SW118	SW68793	2083514	751533	Surface water storm event
SW093	SW69293	2085005	751722	Surface water storm event
GS13	SW69393	2086091	751876	Surface water storm event
SW091B	SW69093	2086301	751610	Surface water storm event
GS09	SW68693	2088380	751055	Surface water storm event
GS10	SW68893	2086289	750227	Surface water storm event
SW022	SW68993	2086438	749759	Surface water storm event

TABLE 2 10
OU6 PHASE I STREAM SURFACE WATER (BASEFLOW/STORM EVENT) AND SEDIMENT SAMPLE SURVEY COORDINATES

ORIGINAL STATION ID	SITE NUMBERS	SITE LOCATION State Easting	SITE LOCATION State Northing	SAMPLE TYPES
Stream Sediment Sampling				
SW116	SED69492	2081072	750875	Stream Sediment
SW118	SED69692	2083514	751533	Stream Sediment
SW093	SED68592	2085005	751722	Stream Sediment
GS13	SED68492	2086091	751876	Stream Sediment
SW091B	SED68192	2086301	751610	Stream Sediment
GS12	SED68692	2088575	752632	Stream Sediment
GS11	SED68792	2089964	753270	Stream Sediment
GS03	SED69392	2093618	753646	Stream Sediment
GS09	SED69792	2088380	751055	Stream Sediment
GS10	SED69892	2086289	750227	Stream Sediment
SW103	SED69992	2088786	750848	Stream Sediment
SW022	SED70092	2086438	749759	Stream Sediment
#1	SED68992	2090219	753616	Stream Sediment
#2	SED69292	2091343	754080	Stream Sediment
#3	SED68892	2090269	753441	Stream Sediment
Baseflow Surface Water Sampling				
SW116	SW67093	2081072	750875	Surface water baseflow
SW118	SW67493	2083514	751533	Surface water baseflow
SW093	SW67193	2085005	751722	Surface water baseflow
GS13	SW67393	2086091	751876	Surface water baseflow
SW091B	SW68193	2086301	751610	Surface water baseflow
GS12	SW68093	2088575	752632	Surface water baseflow
GS11	SW67893	2089964	753270	Surface water baseflow
GS03	SW67993	2093618	753646	Surface water baseflow
GS09	SW67693	2088380	751055	Surface water baseflow
GS10	SW67593	2086289	750227	Surface water baseflow
#2	SW68293	2091343	754080	Surface water baseflow
Storm Event Surface Water Sampling				
SW116	SW68593	2081072	750875	Surface water storm event
SW118	SW68793	2083514	751533	Surface water storm event
SW093	SW69293	2085005	751722	Surface water storm event
GS13	SW69393	2086091	751876	Surface water storm event
SW091B	SW69093	2086301	751610	Surface water storm event
GS09	SW68693	2088380	751055	Surface water storm event
GS10	SW68893	2086289	750227	Surface water storm event
SW022	SW68993	2086438	749759	Surface water storm event

TABLE 2 2 1
OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSS 141 Sludge Dispersal Area	Review Existing Data	Provide baseline information to guide field activities	Reviewed HRR and aerial photographs	N/A
	Radiation survey	Locate areas of anomalous radiation readings	17 point FIDLER survey performed prior to surface soil sampling HPGE survey conducted later	N/A
	Collect surface soil samples on 25 foot grid spacing and at locations with anomalous radiation readings	Characterize surface soil contamination	40 soil samples collected as proposed	N/A
	Install one alluvial monitoring well	Monitor downgradient alluvial groundwater	Installed one colluvial well	No alluvial material was encountered in boring
	Install one bedrock well if water bearing sandstone is uppermost bedrock unit	Monitor downgradient bedrock groundwater	Not installed Sandstone not present beneath colluvium	N/A

TABLE 2 2-1

OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSSs 142 1 through 9 and 142 12 A and B Series and W&I Ponds	Review existing data (surface water and sediment) collected as part of RFETS monitoring program	Assess if data from monitoring program satisfies OU 6 program requirements	As specified in TM1 existing RFETS monitoring stations satisified OU 6 stream sampling sites	N/A
	Collect pond surface water samples from five locations and from each vertically stratified zone at the deepest point of each pond	Characterize surface water contamination in ponds	51 samples collected as proposed Stratification observed at site SW62892 in Pond B 2	N/A
	Collect pond sediment samples from five locations in each pond	Characterize sediments contamination in ponds	Samples collected as proposed	N/A
	Perform gamma radiation screening on sediment core collected from deepest part of each pond	Assess vertical distribution of gamma-emitting radionuclides in pond sediments in deepest part of ponds	As proposed	N/A
	Collect two dry sediment samples at the inlet area of each A and B Series Pond	Characterize contamination in dry sediments in inlet areas	18 samples collected as proposed	N/A
	Collect stream surface water samples during base flow conditions at locations specified in TM1	Characterize contaminants potentially loading surface water in Walnut Creek drainages	11 surface water samples collected at 11 of 15 locations specified in TM1	4 locations were dry

TABLE 2 2 1

OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSSs 142 1 through 9 and 142 12 A and B Series and W&I Ponds	Collect stream sediment samples during base flow conditions at locations specified in TM1	Characterize contamination in stream sediment in Walnut Creek drainages	15 sediment samples collected at 15 locations specified in TM1	N/A
	Collect stream surface water samples during storm event conditions at locations specified in TM1	Characterize contaminants potentially loading surface water in Walnut Creek drainages during storm events	8 surface water samples collected at 15 locations specified in TM1	7 locations dry or had insufficient water flow
	Install one alluvial well downgradient of each of the dams for Ponds A 4 and B 5 Install a bedrock well adjacent to the alluvial well if sandstone bedrock underlies the alluvium	Monitor alluvial groundwater and bedrock groundwater if present	Installed one bedrock well near the Pond A 4 Dam and one alluvial well near the Pond B 5 Pond Dam	No alluvial well installed near the Pond A 4 because existing alluvial well 1186 is near the proposed location
	Install six bedrock wells	Characterize the bedrock	Not installed TM1 omitted bedrock wells and substituted dams investigation wells in their place	N/A

TABLE 2 2 1

OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSS 143 Old Outfall Area	Surface soil sampling at four of the soil boring locations	Characterize surface soil quality	As proposed	N/A
	Subsurface soil sampling in each of seven borings	Characterize soil quality in upper 2 feet of pre fill surface	39 samples collected in soil borings drilled in Old Outfall Area	Old Outfall Area location based on Stage 1 review of historical aerial photographs and site plans Some sample locations inaccessible or obstructed
	Fill material to be composite sampled from every fourth boring	Characterize soil quality in fill material	1 sample collected as proposed	N/A
	Install alluvial well downgradient of Old Outfall Area	Monitor alluvial groundwater downgradient of Old Outfall Area	As proposed	N/A
IHSS 156 2 Soil Dump Area	Review aerial photographs	Identify boundaries of site	As proposed	N/A
	Radiation survey	Locate areas of anomalous radiation readings	17 point FIDLER survey performed prior to sampling at each surface soil and soil boring location Germanium survey performed later	As per EG&G

TABLE 2 2-1

OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSS 156 2 (continued)	Collect surface soil samples from grid with 150 foot spacing	Characterize surface materials and contamination	22 samples collected	No samples collected from paved or inaccessible areas
	Collect subsurface samples from same locations as surface soil samples	Characterize subsurface materials and contamination	181 samples collected	N/A
	Install alluvial well	Monitor alluvial groundwater within the unit	As proposed	N/A
	Install bedrock well in sandstone if present at bedrock contact	Monitor bedrock groundwater and characterize the hydraulic properties of the sandstone	Not installed Sandstone not present at bedrock contact	N/A
	Soil classification survey	For environmental evaluation	As proposed	N/A
IHSS 165 Triangle Area	Review aerial photographs	Identify boundaries of site	As proposed	N/A
	Radiation survey	Locate areas of anomalous radiation readings	17 point FIDLER survey was performed prior to sampling Germanium survey was conducted at a later date outside the PA	Due to large amounts of equipment and construction debris the area was inaccessible inside the PA

TABLE 2 2-1

OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSS 165 (continued)	Soil gas survey	Evaluate presence or absence of VOCs	31 soil gas samples collected on a 100-foot grid spacing	A 100-foot grid spacing resulted in 31 sample points in the IHSS rather than 56 as specified in Work Plan A reduced spacing was not used around SGS 70392
	Collect 15 surface soil samples at random locations outside the PA security fence area	Supplement lack of radiation survey in gravel covered areas	15 samples collected at random throughout IHSS 165	N/A
	Collect one soil core for every 15 soil gas samples	Confirm soil gas survey results	4 soil cores collected	N/A
	Soil classification survey	For environmental evaluation	As proposed	N/A
	Drill up to nine soil borings based on soil gas survey results	Transect plumes identified by soil gas survey or confirm negative results	Nine boreholes drilled 112 samples collected	N/A
	Collect one sediment sample adjacent to surface water station SW 91	Characterize sediments in ditch discharging north to A Series Ponds	As proposed	N/A

TABLE 2 2 1

OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSS 165 (continued)	Install two alluvial wells east and west of PA fence within unit	Monitor alluvial groundwater under unit	Installed one alluvial well east of PA security fence	Did not install alluvial well west of PA security fence because existing well 2986 served that purpose
	Install bedrock well west of PA fence into sandstone if present	Monitor groundwater in bedrock sandstone if present	Installed one bedrock well	N/A
IHSS 166 Trenches A B & C	Review aerial photographs	Identify location and extent of trenches	As proposed	N/A
	Geophysical EM survey	Locate and delineate extent of trenches	As proposed	N/A
	Collect subsurface samples from soil borings drilled every 25 feet along the axes of the trenches	Characterize materials and contamination in trenches	26 borings drilled as proposed	N/A
	Soil classification survey	For environmental evaluation	As proposed	N/A
	Install two alluvial wells downgradient of Trench B and C	Monitor alluvial groundwater downgradient of the trenches	Alluvial wells installed approx 300 feet east and 70 feet northeast of Trenches B and C respectively	Wells were drilled in more favorable locations
	Install bedrock well in sandstone if present	Monitor groundwater in bedrock sandstone	Not installed Sandstone not present at bedrock contact	N/A

TABLE 2 2-1

OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSSs 167 1 and 167 3 North and South Spray Field Areas	Review aerial photographs	Identify location and extent of the units	As proposed	N/A
	Collect surface samples from entire site on 100 foot grid	Characterize surface contamination	31 samples collected	N/A
	Collect subsurface samples from soil borings drilled on 100 foot grid to 4 feet depth	Characterize subsurface conditions and contamination	30 samples collected	Soil boring 62892 drilled to 3 8 feet only due to refusal One soil boring not drilled because of steep terrain and inaccessibility for a drill rig
	Soil classification survey	For environmental evaluation	As proposed	N/A
	Collect sediment samples within the drainage downstream of units	Characterize sediments and contamination downgradient	Not collected	These samples were omitted as specified in TM1
	Collect two surface water samples downgradient of North and South Area Spray Fields	Characterize surface water downgradient of units	Not collected	These samples were omitted as specified in TM1

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TABLE 2 2 1

OU6 IHSS PROPOSED AND COMPLETED PHASE I INVESTIGATIONS

IHSS	Proposed Investigation	Purpose	Completed Investigation	Reason for Deviation
IHSSs 167 1 and 167 3 (continued)	Install two alluvial wells within the drainages downgradient of IHSSs 167 1 and 167 3	Monitor alluvial groundwater downgradient of the spray fields	Installed one colluvial well at 167 1	No alluvial material was encountered in the borehole during drilling
			Installed one alluvial well at 167 3	N/A
	Install bedrock well in weathered bedrock sandstone if present and alluvium is dry	Monitor groundwater in weathered sandstone bedrock	Not installed Sandstone not present at bedrock contact	N/A
IHSS 216 1 East Spray Field Area	Collect surface samples from entire site on 200 foot grid	Characterize surface contamination	6 samples collected	N/A
	Collect subsurface samples from soil borings drilled on 200 foot grid to 4 feet depth	Characterize subsurface conditions and contamination	22 samples collected	N/A
	Install downgradient alluvial well	Monitor alluvial groundwater downgradient of spray field if contamination is present	Not installed No contamination was found therefore well was not installed	N/A

TABLE 2.2-2
OU6 PHASE I POND WATER AND SEDIMENT SAMPLING SITES, SAMPLE NUMBERS AND SEDIMENT SAMPLE DEPTHS

IHSS	SAMPLING SITE NUMBER	SAMPLE NUMBER	DEPTH INTERVAL
IHSS 142 1	SED60092	SD60000WC	0 0'-18 0"
POND A 1	SED60192	SD60001WC	0.0"-16 3"
	SED60292	SD60002WC	0 0"-19 3"
	SED60392	SD60003WC	0 0'-20.0"
	SED60492	SD60004WC	0 0"-13 5"
	SED65092	SD60050WC	0 0"-2 0"
	SED65192	SD60051WC	0 0 -2 0
	SW60092	SWU6000WC	
	SW60192	SWU6001WC	
	SW60292	SWU6002WC	
	SW60392	SWU6003WC	
	SW60492	SWU6004WC	
IHSS142 2	SED60592	SD60005WC	0 0 -7 5
POND A 2	SED60692	SD60006WC	0 0"-8.5"
	SED60792	SD60007WC	0 0"-6 0
	SED60892	SD60008WC	0 0"-6 0"
	SED60992	SD60009WC	0 0"-8 0"
	SED65292	SD60052WC	0 0"-2 0"
	SED65392	SD60053WC	0 0"-2 0"
	SW60592	SWU6005WC	
	SW60692	SWU6006WC	
	SW60792	SWU6007WC	
	SW60892	SWU6008WC	
	SW60992	SWU6009WC	
IHSS142 3	SED61092	SD60010WC	0 0 -22 7"
POND A 3	SED61192	SD60011WC	0 0" 14 4"
	SED61292	SD60012WC	0 0"-12 4'
	SED61392	SD60013WC	0 0"-14 1"
	SED61492	SD60014WC	0,0"-12 0
	SED65492	SD60054WC	0 0'-2 0"
	SED65592	SD60055WC	0 0"-2 0"
	SW61092	SWU6010WC	
	SW61192	SWU6011WC	
	SW61292	SWU6012WC	
	SW61392	SWU6013WC	
	SW61492	SWU6014WC	
IHSS142 4	SED61592	SD60015WC	0 0"-6 3'
POND A-4	SED61692	SD60016WC	0 0 2 8
	SED61792	SD60017WC	0 0"-6 6
	SED61892	SD60018WC	0 0" 2 8"

TABLE 2 2-2
OU6 PHASE I POND WATER AND SEDIMENT SAMPLING SITES, SAMPLE NUMBERS AND SEDIMENT SAMPLE DEPTHS

IHSS	SAMPLING SITE NUMBER	SAMPLE NUMBER	DEPTH INTERVAL
	SED61992	SD60019WC	0 0 9 4
IHSS 142 4	SED65692	SD60056WC	0 0 2 0
(continued)	SED65792	SD60057WC	0 0 2 0
	SW61592	SWU6015WC	
	SW61692	SWU6016WC	
	SW61792	SWU6017WC	
	SW61892	SWU6018WC	
	SW61992	SWU6019WC	
IHSS 142 5	SED62092	SD60020WC	0 0 24 0
POND B 1		SD60125WC	24 0 29 0
	SED62192	SD60021WC	0 0 11 0
	SED62292	SD60022WC	0 0 24 0
		SD60126WC	24 0 28 0
	SED62392	SD60023WC	0 0 18 0
	SED62492	SD60024WC	0 0 18 0
	SED65892	SD60058WC	0 0 2 0
	SED65992	SD60059WC	0 0 2 0
	SW62092	SWU6020WC	
	SW62192	SWU6021WC	
	SW62292	SWU6022WC	
	SW62392	SWU6023WC	
	SW62492	SWU6024WC	
IHSS 142 6	SED62592	SD60025WC	0 0 20 0
POND B 2	SED62692	SD60026WC	0 0 8 0
	SED62792	SD60027WC	0 0 6 0
	SED62892	SD60028WC	0 0 14 0
	SED62992	SD60029WC	0 0 -15 0
	SED66092	SD60060WC	0 0 2 0
	SED66192	SD60061WC	0 0 2 0
	SW62592	SWU6025WC	
	SW62692	SWU6026WC	
	SW62792	SWU6027WC	
	SW62892	SWU6028WC	0 0 24 0
		SWU6061WC	24 0 54 0
	SW62992	SWU6029WC	
IHSS 142 7	SED63092	SD60030WC	0 0 12 5
POND B 3	SED63192	SD60031WC	0 0 16 0
	SED63292	SD60032WC	0 0 -24 0
		SD60118WC	24 0 31 0
	SED63392	SD60033WC	0 0 24 0

TABLE 2 2-2
OU6 PHASE I POND WATER AND SEDIMENT SAMPLING SITES, SAMPLE NUMBERS AND SEDIMENT SAMPLE DEPTHS

IHSS	SAMPLING SITE NUMBER	SAMPLE NUMBER	DEPTH INTERVAL
		SD60116WC	24 0"-25.5"
	SED63492	SD60034WC	0 0 -6 4"
IHSS 142 7	SED66292	SD60062WC	0 0"-2 0"
(continued)	SED66392	SD60063WC	0 0 -2 0"
	SW63092	SWU6030WC	
	SW63192	SWU6031WC	
	SW63292	SWU6032WC	
	SW63392	SWU6033WC	
	SW63492	SWU6034WC	
IHSS 142 8	SED63592	SD60035WC	0 0"-24 0"
POND B-4		SD60111WC	24 0 -28 3
	SED63692	SD60036WC	0 0"-15 9"
	SED63792	SD60037WC	0 0" 24 0
		SD60114WC	24 0 -31 5
	SED63892	SD60038WC	0 0" 24 0'
		SD60110WC	24 0 30 9"
	SED63992	SD60039WC	0 0" 12 9
	SED66492	SD60064WC	0 0"-2.0
	SED66592	SD60065WC	0 0'-2 0
	SW63592	SWU6035WC	
	SW63692	SWU6036WC	
	SW63792	SWU6037WC	
	SW63892	SWU6038WC	
	SW63992	SWU6039WC	
IHSS 142 9	SED64092	SD60040WC	0 0 -8 5
POND B 5	SED64192	SD60041WC	0 0 -5 6"
	SED64292	SD60042WC	0 0 -8 4"
	SED64392	SD60043WC	0 0"-8 8"
	SED64492	SD60044WC	0 0"-2 5"
	SED66692	SD60066WC	0 0 -2 0
	SED66792	SD60067WC	0 0 -2 0"
	SW64092	SWU6040WC	
	SW64192	SWU6041WC	
	SW64292	SWU6042WC	
	SW64392	SWU6043WC	
	SW64492	SWU6044WC	
IHSS 142 12	SED64592	SD60045WC	0 0 -11 5
W&I POND	SED64692	SD60046WC	0 0"-22 0"
	SED64792	SD60047WC	0 0"-5 0
	SED64892	SD60048WC	0 0" 11 0

TABLE 2 2-2
OU6 PHASE I POND WATER AND SEDIMENT SAMPLING SITES, SAMPLE NUMBERS AND SEDIMENT SAMPLE DEPTHS

IHSS	SAMPLING SITE NUMBER	SAMPLE NUMBER	DEPTH INTERVAL
	SED64992	SD60049WC	00 70
	SW64592	SWU6045WC	
	SW64692	SWU6046WC	
IHSS 142 12	SW64792	SWU6047WC	
(continued)	SW64892	SWU6048WC	
	SW64992	SWU6049WC	

VOCs Volatile Organic Compounds
SVOCs Semi Volatile Organic Compounds
NO2/NO3 as N Nitrate/Nitrite as N
TOC Total Organic Carbon
Rads Radionuclides
H3 Tritium
MS/MSD Matrix Spike / Matrix Spike Duplicate
LR Lab Replicate (Radiochemistry Only)

3 0
PHYSICAL CHARACTERISTICS OF OU6

This section describes the physical characteristics of RFETS and OU6 Included are discussions of physiographic features demography and land use meteorology and climatology soils geology, hydrogeology, surface water, and ecology

3 1 PHYSIOGRAPHIC FEATURES

3 1 1 Regional

RFETS is located at an elevation of approximately 6 000 feet above mean sea level (MSL) on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Fenneman 1931) The Colorado Piedmont ranges from an elevation of 4,000 feet MSL in the east to an elevation of 7 000 feet MSL in the west The piedmont merges to the east with the High Plains section of the Great Plains Province and is terminated abruptly on the west by the Front Range section of the Southern Rocky Mountain Province

The Colorado Piedmont is an area of dissected topography and denudation representing an old erosional surface along the eastern margin of the Rocky Mountains The piedmont surface is broadly rolling and slopes gently to the east with a topographic relief of only several hundred feet This relief is due both to resistant bedrock units that locally rise above the surrounding landscape and to the presence of incised stream valleys Major stream valleys that transect the piedmont from west to east have their origin in the Front Range Small local valleys have developed as tributaries to these major streams within the piedmont

The eastern margin of the Front Range, a few miles west of RFETS is characterized by a narrow zone of hogback ridges and flatirons formed by steeply east-dipping strata, such as the Dakota Sandstone (Cretaceous) and the Fountain Formation (Permian and Pennsylvanian) Less resistant sedimentary units were removed by erosion Approximately 15 miles west of the hogback ridges and flatirons the Front Range reaches elevations of 12,000 to 14,000 feet above MSL The range itself is broad and underlain by resistant gneiss, schist, and granitic rocks of Precambrian age The resistant nature of these rocks has restricted stream erosion so that deep narrow canyons have developed in the Front Range

Several pediments were developed across both hard and soft bedrock in the area of RFETS during the Quaternary period (Scott 1963) The Rocky Flats pediment is the most extensive of these, forming a broad flat surface south of Coal Creek The broad pediments and narrow terraces are covered by thin alluvial deposits of ancient streams that once drained eastward into the Great Plains The sequence of pediments reflects repetitive physical processes associated with cyclic changes in climate Each erosional surface and stratigraphic sequence deposited on it probably represents a single glacial cycle The oldest and highest pediment, the Subsummit Surface (Scott 1960), truncates the hogback ridges of the Front Range Three successively younger pediments, veneered by alluvial gravels (including the Rocky Flats Alluvium), extend eastward from the mountain front Erosion of valleys into the pediments followed each depositional cycle so that near the mountain fronts, stratigraphically younger geologic units occur at topographically lower elevations as narrow terrace deposits along the streams These alluvial deposits in the OU6 area are described in Section 3 5 1

The security area of RFETS is located on a relatively flat surface of Rocky Flats Alluvium (Figure 3 1-1) The pediment surface has been eroded by Walnut Creek on the north and Woman Creek on the south subsequently, terraces along these streams range in height from 50 feet to 150 feet The grade of the gently eastward-sloping surface of the Rocky Flats Alluvium varies from 0 7 percent in the security area of RFETS to approximately 2 percent just east of the security area

3 1 2 Operable Unit No 6

The OU6 study area covers approximately 1,061 acres, consisting of east-west trending valleys and ridges Three east-flowing drainages cross the OU6 site an unnamed tributary, North Walnut Creek and South Walnut Creek (Figure 1 3-2) All three drainages meet near the eastern border of OU6 to form Walnut Creek Two east-west trending ridges, bordered by these three drainages, terminate west of the confluence of the three drainages

The OU6 area is bounded by the unnamed tributary on the north Indiana Street on the east, the South Walnut Creek drainage on the south and the RFETS complex and Landfill (IHSS 114) on the west (Figure 3 1-1) The topography generally slopes from west to east, with elevations varying from 5,973 feet to 5,636 feet MSL

3 2 DEMOGRAPHY AND LAND USE

3 2 1 Demographics

Demographic information described below is primarily taken from "1989 Population, Economic, and Land Use Data for Rocky Flats Plant" (DOE 1990b), developed by the Denver Regional Council of Governments (DRCOG) This DRCOG study encompassed a 50-mile radius area from the center of RFETS and included all or part of 14 counties and 72 incorporated cities with a 1989 combined population of 2,206 550

RFETS is located in a rural area of unincorporated Jefferson County approximately 16 miles northwest of Denver and approximately 10 miles south of Boulder RFETS is situated on a 6 550-acre parcel of federally owned land The security area of the facility is located in the approximate center of the parcel and is surrounded by a buffer zone of approximately 6,150 acres The area west of RFETS is mountainous and sparsely populated The area east of RFETS is generally a high arid plain and is densely populated The majority of the population included in the DRCOG study is located within 30 miles of RFETS, to the east and southeast in the Denver metropolitan area The majority of the development of the plains to the east of RFETS has occurred since the plant was built

Within a 6 4-mile radius of the center of RFETS there is little residential or commercial development Between 4 and 10 miles, development increases, with approximately 316,000 residents within a 10-mile radius The most significant development exists to the southeast in the cities of Westminster Arvada, and Wheat Ridge The cities of Boulder, to the northwest Broomfield Lafayette and Louisville to the northeast and Golden to the south also contain significant developments within this 10-mile radius (DOE 1990b)

Recent population estimates registered by DRCOG for the eight-county Denver metropolitan area display distinct growth patterns Between 1980 and 1985 the population of the metropolitan area increased by 197,890, a 2 4 percent annual growth rate Between 1985 and 1989, a population gain of 71 575 was recorded, representing a 1 0 percent annual increase (the national average) The 1989 population showed an increase of 2,225 (or 0 1 percent) over the previous year (DRCOG 1989)

The DRCOG study also projected populations through the year 2010 Figure 3 2-1 (DOE 1990b) illustrates the 1989 residential population found within a 5-mile radius of RFETS The 2010 projected residential population is illustrated in Figure 3 2-2 (DOE 1990b) Sectors 1 and 2 represent land within the RFETS boundary Sectors 3, 4, and 5 represent property outside the RFETS boundary Radial Segments E and F are the general area of OU6 Radial Segments D through I represent the predominant downwind and downstream directions from the OU6 area Table 3 2-1 summarizes the 1989 and projected 2010 population data shown in Figures 3 2-1 and 3 2-2, as well as the 1989 and projected 2010 population for the region within the 5- to 10-mile radius of RFETS The information presented in Table 3 2-1 indicates that zero population growth is projected for the next 20 years in the areas immediately adjacent to the RFETS boundary (Sector 3)

Eight public schools are within six miles of RFETS The nearest school is Witt Elementary School, which is approximately 2 7 miles east of the RFETS buffer zone (DOE 1991c) There are 93 schools, 8 nursing homes, and 4 hospitals within a 10-mile radius of RFETS (DOE 1990b)

The nearest drinking water supply is Great Western Reservoir, located approximately 2 3 miles to the east of the center of RFETS The City of Broomfield operates a water treatment facility immediately downstream from Great Western Reservoir This facility supplies drinking water to approximately 28,000 persons Standley Lake, a drinking water supply for the cities of Thornton, Northglenn, Westminster, and Federal Heights, is located 3 5 miles to the southeast of RFETS in the Woman Creek drainage

3 2 2 Off-Site Land Use

3 2 2 1 Current Land Use

Current land use within a 10-mile radius of RFETS is described in "1989 Population, Economic and Land Use Data for Rocky Flats Plant" (DOE 1990b) In general, current land use surrounding RFETS includes open space (recreational), agricultural, residential, and commercial/industrial Open space (recreational) land includes an open space parcel to the northwest owned by the City of Boulder Golden Gate State Park to the west White Ranch Park to the south Standley Lake Park to the southeast and other open space lands to the southeast associated with Westminster and Arvada The majority of the agricultural land is located to the northeast of RFETS Some agricultural land is also located east of RFETS while parcels of range land are located to the southwest The majority of residential land use is 4 to 10 miles to the southeast The primary commercial/industrial area within 5 miles of RFETS is the Jefferson County Airport area Additional commercial/industrial areas within 10 miles of RFETS include areas in Westminster and Arvada to the east and south, Broomfield to the east Lafayette and Louisville to the northeast Boulder to the northwest and Golden to the south The northeastern Jefferson County and RFETS area is currently one of the most concentrated areas of industrial development in the Denver metropolitan area.

Current land use in the area immediately southeast of OU6 includes all of the uses mentioned above, with the predominant uses appearing to be open space single-family detached dwellings and agricultural (livestock) operations Industrial facilities within 5 miles of RFETS include the TOSCO Laboratory Thoro Products, the Great Western Inorganics Plant which forms part of the Rocky Flats Industrial Park (2 miles south), the Western Aggregates, Inc Plant (2 4 miles northwest), and the Jefferson County Airport and Industrial Park (a 990-acre site located 4 8 miles northeast)

3 2 2 2 Future Land Use

Future land use is generally expected to follow existing land use patterns The North Plains Community Plan (Jefferson County 1990) was prepared to serve as a guide to the county and cities to achieve compatible land use and development decisions regardless of the jurisdiction Jefferson County expects that industrial land uses will continue to dominate the northeastern portion of the county The plan identifies RFETS and the Jefferson County Airport as constraints to future residential developments in the area, and recommends office and light industrial development The plan further identifies the acquisition of lands for open space uses as a high priority for the area, recommending that large amounts of undeveloped land be provided for this purpose (Jefferson County 1990)

Maps presented in the North Plains Community Development Plan (Jefferson County 1990) and the Jefferson Center Comprehensive Development Plan show that the predominant future land uses to the south and southeast of RFETS will consist of commercial, industrial, and office space Directly to the east, the zoning and uses are expected to remain open-space, agricultural, or vacant The areas closest to RFETS are planned for industrial, commercial, or office space, with the areas further from RFETS designated for residential development This planning is consistent with the projected zero residential growth rate in the next 20 years for areas immediately adjacent to RFETS (DOE 1990b)

The cities of Broomfield and Superior have participated in the Jefferson County cooperative planning process and are planning business, industrial, and mixed land uses for the area north of RFETS (Jefferson County 1990, City of Broomfield 1990, Boulder County 1991)

3.2.3 Onsite Land Use

3 2 3 1 Current Land Use

RFETS production and maintenance activities occur in only 13 percent of the OU6 area. Current activities in the OU6 area consist of environmental investigations, water detention, treatment and testing, sludge treatment storage, and routine security surveillance

Seven of the seventeen OU6 IHSSs within the buffer zone are not currently active These include IHSSs 167 1, 167 3, and 216 1 (North, South and East Spray Field Areas, respectively), IHSSs 166 1 166 2 and 166 3 (Trenches A, B, and C respectively), and IHSS 156 2 (Soil Dump Area) Ten of the IHSSs within the buffer zone are currently in use Nine of these are detention ponds (IHSSs 142 1-142 9), which are currently being used to control runoff and detain water before being released into Walnut Creek IHSS 142 12 is used as a final water quality check point, prior to release of water off site

IHSSs 141 143 and 165 are inside the PA of RFETS Paved patrol roads traverse part of IHSS 141 IHSS 143 currently has several trailers located on it IHSS 165 is currently a storage area for miscellaneous materials Approximately one-fifth of IHSS 165 and a small portion of IHSS 141 are located in a protected zone which is 100-feet wide and has an inner and outer fence The PA security fence zone is inaccessible

3 2 3 2 Future Land Use

Occupation by private industry is being considered by DOE for the future use of the onsite RFETS production area Areas of OU6 immediately adjacent to the industrial portion of RFETS could be considered as part of future industrial development With the present open space located nearby it is plausible that the buffer zone will be preserved as open space Ecological surveys of the buffer zone performed in compliance with the Threatened and Endangered Species Act and wetlands assessment may indicate the presence of several listed species at RFETS Because the buffer zone has not been impacted by commercial development except for aggregate mining on the west side of the plant, the future use of this area as an ecological preserve is feasible This type of site use is also consistent with the Jefferson County Planning Department's recommendations for the provisions of large amounts of undeveloped land in the area (Jefferson County 1990)

3 3 METEOROLOGY AND CLIMATOLOGY

The RFETS area has a semiarid climate that is characteristic of much of the central Rocky Mountain region Table 3 3-1 presents the annual climatic summary compiled for 1993 (DOE 1993a) The annual precipitation at RFETS for 1993 is estimated at 12 07 inches (DOE 1993a) Approximately 34 percent of the annual precipitation falls during the spring season, and much of this precipitation is snow Thunderstorms (June to August) account for an additional 22 percent of the annual precipitation Autumn and winter account for 35 percent and 9 percent of the annual precipitation respectively Snowfall averages approximately 65 inches per year and typically occurs from October through May (DOE 1993a)

Temperatures are typically moderate Extremely warm or cold weather is rare and of short duration On the average daily summer temperatures range from 52 to 76 degrees

Fahrenheit, and winter temperatures range from 18 to 39 degrees Fahrenheit The low average relative humidity (42 percent) is due to the blocking effect of the Rocky Mountains.

The wind flow around RFETS is strongly influenced by the close proximity of the Rocky Mountains and High Plains, which produce a diurnal cycle of wind patterns (upslope and downslope) when there are no strong storm systems or synoptic patterns within the region The east-west trending canyons to the west of RFETS can further channel the local wind directions Nighttime wind directions generally flow downslope from the mountains to the plains, while daytime wind directions may flow upslope The South Platte River Valley is the area for the confluence and divergence of the airflow patterns for the region between the Front Range and the Denver Metropolitan area. Chinook windstorms may occur during the spring, as winds moving from west to east over the Continental Divide plunge down the east side of the mountain slopes

Table 3 3-2 is an annual joint frequency distribution of the wind direction categorized by six wind speed classes at RFETS, based on the pre-processed meteorological data for 1993 These data are presented as a wind rose in Figure 3 3-1 Compass point designations indicate the true bearing when facing the wind (direction from which the wind flows) Figure 3 3-1 shows that northwest winds are predominant at RFETS (DOE 1993a)

Pasquill-Gifford atmospheric stability classes at RFETS were calculated using the Sigma Theta method, which categorizes the class of stability as a function of the standard deviation of horizontal wind direction by horizontal wind speed and time of day Table 3 3-2 presents the 1993 RFETS meteorological data by stability indexes or classes The classes range from A to F, extremely unstable to moderately stable, respectively The D class represents neutral stability characteristics The data show that unstable characteristics (A through C) occur about 25 percent of the time Stable cases (E and F) occur about 32 percent of the time Thus neutral conditions (D) occur at RFETS approximately 43 percent of the time (DOE 1993a)

3 4 SOILS

Soils within the OU6 area have been classified by the Soil Conservation Service, Department of Agriculture (DOA 1980) The location and lateral extent of these soil types within the

OU6 area were digitized from Digital Line Graph (DLG) data from the Soil Conservation Service (Digital ARC/Info Coverage provided by EG&G RFETSSOIL Coverage) and are presented in Figure 3 4-1 Table 3 4-1 lists the major soil units within the OU6 area, with their classifications and properties

Most of the soil series shown on Table 3 4-1 are classified within the Argiustoll great group Argiustolls are generally characterized as well-drained soils with dark-colored, humus-rich surface "A" horizons, argillic "B" horizons, and calcic "C" horizons They exist in aridic and ustic (limited moisture) regimes which are adequate for plant growth during the growing season The two predominant subgroups are Torretic and Aridic Torretic Argiustolls typically have a higher shrink-swell potential than Aridic Argiustolls (DOA 1980)

The predominant soil type within OU6 are clay loams of the Denver-Kutch-Midway group (DOA 1980) These soils occur along the drainages of the unnamed tributary, South Walnut Creek, and North Walnut Creek (Figure 3 4-1) Slope gradients for these soils range from 9 to 25 percent with the Denver and Kutch soils typically located on the hillslopes of the drainages, while the Midway soils are found on the ridge crests The Denver clay loams consist of deep well-drained, calcareous clay, silty clay and sandy clay material derived primarily from claystones siltstones and sandstones The Kutch soils are moderately deep, well-drained, calcareous clayey alluvium and colluvium derived from claystones, siltstones, and sandstones and from Rocky Flats Alluvium (RFA) and terrace alluviums The Midway clay loams are shallow well-drained calcareous clayey material derived from RFA These soils have low permeability and infiltration rates which result in a severe water erosion hazard

Within the flood plain near the confluence of the Walnut Creek drainages the Englewood clay loam is the predominant soil type (Figure 3 4-1) The Englewood clay loam is deep and well drained, consisting of calcareous clayey alluvium derived from claystones, siltstones, and sandstones and from RFA and terrace alluviums in the OU6 area (DOA 1980) This soil forms flat (0 percent) to moderate (5 percent) slopes in the Walnut Creek confluence area, with an associated slight water erosion hazard Shrink-swell potential for these soils tends to be high

The North Walnut Creek drainage upgradient of the Pond A-3 dam and associated terraces (0 to 3 percent slopes) are covered by the Haverson loam (Figure 3 4-1) This soil type is also present in the area of the Walnut Creek-McKay Ditch confluence The Haverson loam is a deep, well-drained, stratified alluvium derived from RFA and terrace alluviums; and bedrock claystones, siltstones, and sandstones (DOA 1980) The infiltration rate and permeability for this soil is slow and moderate/slow, respectively This soil type is associated with slight water erosion hazards and low shrink-swell potential

The Leyden-Primen-Standley cobbly clay loams (15 to 50 percent slopes) have limited areal extent on the northern hillside near Pond B-5 in the South Walnut Creek Drainage (Figure 3 4-1) The Leyden-Primen-Standley series is derived from RFA, terrace alluvium, and bedrock claystones The soil consists of clayey, gravelly, stony and cobbly material, which constitute clayey, montmorillonitic, mesic Andic Argiustolls This series displays a slow infiltration and a slow permeability, severe water erosion hazard, and moderate to high potential for shrinkage-swelling Leyden soils are moderately deep and well-drained, consisting of calcareous, cobbly and clayey material The Primen soils are shallow and well-drained Standley soils are deep and well-drained (DOA 1980)

The Flatirons very cobbly sandy loams (0 to 3 percent slopes) are only found on ridge tops that consist predominantly of RFA IHSSs 167 1, 166 1, 166 3, 165, and 156 2 are all characterized by this soil type The Flatirons soil is deep and well-drained, and is formed in non-calcareous cobbly, stony, gravelly, and loamy material of the RFA Slow infiltration rate slow permeability, slight water erosion hazard, and a moderate shrink-swell potential are associated with this soil type

The Valmont soil type is found in IHSS 216 1, on the ridge north of South Walnut Creek above Ponds B-3 and B-4 (Figure 3 4-1) This soil consists of deep, well-drained clay loam derived from RFA and formed in calcareous clayey alluvium underlain by calcareous, very cobbly or very gravelly material Valmont soil has a slow infiltration rate, slow to moderate permeability, slight water erosion hazard, and variable shrink-swell potential

The Nederland soil skirts the Flatiron soils along the ridges and hillsides of the OU6 area and consists of very cobbly sandy loam which forms slopes of 15 to 50 percent This soil is deep and well-drained, and formed in cobbly, gravelly and loamy alluvium derived from the RFA and terrace alluviums This soil has moderate permeability and infiltration rate, a severe water erosion hazard, and low shrink-swell potential

3 5 GEOLOGY

This section presents general descriptions and interpretations of the surface and bedrock geology of the OU6 area Specific geologic descriptions, hydrogeology, and surface water features of each OU6 IHSS and how each relates to the site-wide OU6 geology are discussed in Section 3 9

Geologic information and interpretations presented in this section use data gathered from historical (alluvial and bedrock), Phase I and other ongoing investigations Information on the regional geology of the Front Range and the area surrounding RFETS is included, when needed to assist in the understanding of the local geology

Geologic data obtained from the Phase I OU6 investigation were compared to and supplemented with data from previous studies The previous studies referenced are as follows

- <u>Geotechnical Engineering Report for Geotechnical Analysis of Earthen Dams A-3, B-1, B-3, and Landfill Dam, RFP</u> (EG&G 1993a)

- <u>Phase II Geologic Characterization Data Acquisition Surface Geologic Mapping of the Rocky Flats Plant and Vicinity, Jefferson and Boulder Counties, Colorado</u> (DOE 1992c)

- <u>First Interim Report of Field Activities, Vadose Zone Monitoring, Sanitary Treatment Plant Sludge Drying Beds, Buildings 910 and 995</u> (DOE 1993b)

Geologic interpretations in this section use both surface and subsurface data control Subsurface stratigraphic control was obtained from lithologic logs of core or cuttings collected during the drilling of borings and installation of monitoring wells Pre-1991 core and/or cuttings were logged according to a visual geologic protocol (DOE 1991d) Post-1991 core and/or cuttings were logged systematically and uniformly according to SOP GT 01 (EG&G 1992a)

The OU6 Phase I survey data and ARC/Info Coverage data for the field site locations are contained in Appendix C1 Appendix C2 contains the lithologic logs for the OU6 Phase I borings, wells, and soil cores Stratigraphic data obtained from these lithologic logs are presented on Table 3 5-1, and locations of the borings and wells are shown on Figures 3 5-1 and 3 5-2 The OU6 Phase I monitoring well installation data are listed on Table 2.1-8

The lithologic logs of OU6 borings and monitoring wells drilled prior to the OU6 Phase I investigation are contained in Appendix C3 Appendix C3 also contains lithologic logs (when applicable) of borings and monitoring wells drilled in OUs 2, 4, and 7, concurrently with the OU6 Phase I field investigation Stratigraphic information obtained from the lithologic logs contained in Appendix C3 are presented on Table 3 5-2 The locations of historical boreholes and monitoring wells used in this study are shown on Plate 3 5-1

Additional soil grab samples (11 total) were obtained from various IHSSs specifically for grain size analyses These samples were classified according to SOP GT 01 and the results of the analyses are presented on Table 3 5-3

Pond sediment cores collected during the OU6 Phase I field investigation were classified in the field by visual inspection according to the USCS The pond sediment soil classifications are presented in Table 3 5-4 and the core lithologic data are contained in Appendix C4

The surface geology of OU6 is presented on Plate 3 5-2 Surface geologic control was obtained from field geologic mapping of surface deposits, bedrock outcrops, and air photo interpretation, as discussed in Section 2 1 5 4 Figure 3 5-3 illustrates the local stratigraphic column pertinent to the OU6 area. Shallow stratigraphic units occurring within OU6 consist of the Cretaceous Laramie (Kl) and Arapahoe (Ka) Formations, Quaternary Rocky Flats Alluvium (Qrf), High Terrace Alluvium (Qt) Valley-Fill Alluvium (Qvf), colluvium (Qc), landslides (Qls) These stratigraphic units are shown on Plate 3 5-2 using the abbreviations listed above Qls and man-made deposits (af) Man-made deposits include disturbed ground and artificial fill

Bedrock of the Laramie and Arapahoe Formations is exposed in the valleys that have been incised by the three east-flowing creeks (North Walnut and South Walnut Creeks and the unnamed tributary to Walnut Creek) RFA caps the east-west trending mesas adjacent to these drainages Most of the hillsides are covered by Quaternary colluvium that consists of material from bedrock and RFA Successively younger terrace deposits occur at lower elevations on broader, flatter slopes along the hillsides Additionally, many landslides occur along the hillsides

Stratigraphic units that have greater relevance to OU6 (i e , Laramie, Arapahoe, Rocky Flats Alluvium, Valley-Fill Alluvium, colluvium, landslides, and man-made deposits) are discussed below in greater detail High Terrace Alluvium was not encountered in drilling or sampling during the OU6 Phase I field investigation, however, one historical well, 1886 (Plate 3 5-1) did encounter High Terrace Alluvium High Terrace Alluvium will only be discussed generally to assist in an overall understanding of the OU6 area

3 5 1 Unconsolidated Surface Geologic Units

Unconsolidated surface geologic units of OU6 consist of Quaternary Rocky Flats Alluvium, High Terrace Alluvium Valley-Fill Alluvium, colluvium landslides, and man-made deposits that consist of disturbed ground and artificial fill Plate 3 5-2 illustrates the distribution of the unconsolidated surface deposits in the OU6 study area Stratigraphic and time relationships between the various alluvial deposits are diagrammatically illustrated in Figure 3 5-4 Alluvial deposits include the Pleistocene-age Rocky Flats and High Terrace alluviums, and Pleistocene to Holocene-age Valley-Fill alluviums A diagrammatic cross section of these alluvial deposits in the vicinity of RFETS is shown in Figure 3 5-5 Hillslope deposits consist of Holocene-age colluvium and landslides Figure 3 5-6 is a schematic geologic cross section illustrating a conceptual model of the terrace deposits along South Walnut Creek Geologic cross section A-A' (Figure 3 5-7) which traverses the three OU6 drainages shows the relationships of the unconsolidated surface units to each other and underlying bedrock units Unconsolidated surface geologic units are described below in detail followed by a discussion of bedrock units

3.5 1 1 Rocky Flats Alluvium

The RFA is the topographically highest and the oldest alluvial deposit within the OU6 area. The RFA is generally 10 feet to 50 feet thick although it is as much as 100 feet thick west of RFETS According to Scott (1960) RFA is believed to be Pleistocene (Nebraskan to Aftonian) in age (Figure 3 5-4) The RFA was deposited as large laterally coalescing alluvial fans along the base of the adjacent mountain front (Hurr 1976) These alluvial fans spread eastward over an extensive unconformity or erosional pediment surface that extended eastward from the mountain front Regionally, the pediment surface slopes gently eastward toward the plains, yet locally it can be quite irregular with relief of as much as 50 feet (Malde 1955, Hurr 1976) This local relief is attributed to a well developed network of west-to east-trending paleostream drainages incised into the pediment surface beneath the alluvium (DOE 1991d) Although these paleostream drainages can be determined in other areas of RFETS that have been intensively investigated (i e , OU2), these paleostream drainages are not as well defined in OU6, due to limited subsurface control

The RFA beneath and in the vicinity of RFETS was deposited in an alluvial fan that originates at the mouth of Coal Creek Canyon west of the plant (Malde 1955) Fan deposits can be traced eastward from the mouth of the canyon for approximately 7 miles This deposit and underlying pediment surface have been subsequently dissected by stream erosion along the present drainage systems, leaving remnants of the deposit now capping the mesas between the drainages

The RFA consists primarily of poorly-graded to well-graded clayey gravels, sandy gravels and silty gravels ranging from fine gravel up to 2-inch-diameter cobbles in core samples (2-inch I D split-spoon core), and up to 3-foot-diameter boulders observed in the field The gravel is subrounded to angular and is composed predominantly of quartzite and schist Gravelly, clayey, and silty sands are also present in the alluvium, and are moderately sorted to well sorted, with rounded to angular grains of predominantly quartz, quartzite, and schist Caliche (calcium carbonate precipitate) is commonly present as a coating on gravel and sand grains, as well as disseminated throughout the RFA In some areas, caliche deposits make up as much as 40 percent of the core recovered Table 3 5-5 lists boreholes and monitoring wells that penetrated RFA in the OU6 area. Lithologic variations within the RFA are shown on the lithologic logs (Appendixes C2 and C3) for the borehole and wells listed on Table 3 5-5

3 5 1 2 High Terrace Alluvium

Terrace and Pediment alluviums located topographically below the RFA on the hillsides and slightly broader flat areas, and are mapped together as High Terrace Alluvium (Figure 3 5-4) These terrace deposits are Pleistocene (Kansan to Wisconsin) in age and are further differentiated into the Verdos and Slocum Alluviums (Scott 1960) (Figure 3 5-5) Terrace deposits were formed during interglacial episodes when channels were carved into the upper alluvium by stream runoff leaving younger terrace deposits at lower elevations (Hurr 1976) Erosion by cross-drainages along the hillsides has dissected the terrace deposits, leaving only remnants of formerly laterally-extensive deposits Where a remnant is relatively large or wide (perpendicular to the hillside), the deposit displays a relatively flat top with adjoining steep flanks (Figure 3 5-6) Where a remnant is small in extent, the deposit displays a knoll or mound morphology Some terraces have been almost completely eroded a flat erosional surface with some surface gravels represents the only signs or remnants of the terrace

Lithologically, High Terrace Alluvium deposits exhibit a distinct, fining upward sequence of lithic units This vertical stratification distinguishes these deposits from the surrounding non-stratified colluvium or slopewash High Terrace Alluvium deposits observed in the field usually consist of a basal unit of clayey or sandy gravel overlain by sandy clay clayey sand or an interbedded sequence of both Gravel is subangular to rounded and ranges in size from pebbles to boulders Clays and sands commonly contain carbonaceous matter and roots Caliche commonly occurs throughout the deposit Predominant colors of browns and yellow-browns reflect heavy oxidation Less frequently occurring colors consist of grayish browns, brownish grays, and pale orange The only well (1886) that penetrated High Terrace Alluvium in the OU6 area is listed on Table 3 5-6 (see Appendix C3 for lithologic log)

3 5 1 3 Valley-Fill Alluvium

Valley-Fill Alluvium as defined in this report is Quaternary (Wisconsin to Holocene) age alluvium that occurs within and adjacent to the present drainages (Plate 3 5-2) This designation includes alluvium forming low (less than 40 feet above the creeks) terraces along the drainages The age and stratigraphic relationships between these terraces is illustrated in Figure 3 5-5 Alluvium that may occur within the Valley-Fill designation used in this report include Louviers, Broadway, Pre-Piney Creek, Piney Creek, and Post-Piney Creek Alluviums

Pond sediments within the drainages are also included within the Valley-Fill Alluvium designation

Valley-Fill Alluvium is derived by the reworking and redeposition of RFA, High Terrace Alluvium, colluvium, and bedrock units exposed along the adjacent hillsides Valley-Fill Alluvium within the pond IHSSs (142 1-9, and 142.12) consists of pond sediments (Appendix C4) Valley-Fill Alluvium ranges from 30 feet to 550 feet wide within the drainage for the A-Series Ponds The Valley-Fill Alluvium deposits are more narrowly confined (20 feet to 250 feet wide) along South Walnut Creek upstream from Pond B-5, and within the unnamed tributary At the confluence of Walnut Creek, Valley-Fill Alluvium covers a broad plain adjacent to the creeks Where this broad plain is formed, the low terrace alluviums named above are recognizable

Where penetrated by boreholes, Valley-Fill Alluvium ranges in thickness from less than 1 foot to 10 5 feet in the unnamed tributary, less than 1 foot to 12 5 feet in North Walnut Creek, 5 5 feet to 10 5 feet in South Walnut Creek, and 0 5 feet to 14 7 feet in Walnut Creek Lithologically the Valley-Fill Alluvium consists predominantly of interbedded gravelly sands and sandy-to-clayey gravels The gravel is subangular to subrounded and ranges in size from fine gravel (noted in drill core samples) to boulders (observed in the field, in excavations and roadcuts) Clay, silty to sandy clay, and clayey to silty sand occur in lesser amounts. Gravels and sands are predominantly yellow-brown in color Clay colors are olive- to yellow-gray gray-brown and dark yellow-brown

Figures 3 5-8 (B-B') and 3 5-9 (C-C') are geologic cross sections of North Walnut Creek and South Walnut Creek drainages, respectively These cross sections illustrate the relationships between the unconsolidated surface geologic units and underlying bedrock units in the drainages Boreholes and monitoring wells that penetrated Valley-Fill Alluvium in the OU6 area are listed in Table 3 5-7 Lithologic variations within the Valley-Fill Alluvium are shown on the lithologic logs (Appendixes C2 and C3) for the boreholes and wells listed on Table 3 5-7

3 5 1 4 Colluvium

Colluvium is defined as unconsolidated geologic materials that are predominantly deposited on slopes or at the base of slopes by the transporting action of rainwash, sheetwash, or slow continuous downslope creep (Bates and Jackson 1980) Colluvial deposits at OU6 overlie the eroded bedrock surfaces on the hillsides (Figure 3 5-7) Colluvium within the OU6 area is Holocene in age (Figure 3 5-4) and is the most commonly occurring surface deposit covering the hillsides of the three OU6 drainages (Plate 3 5-2)

Lithologically, colluvium consists predominantly of clay, silty clay and sandy clay The source of this material is the claystones, siltstones and sandstones of the Arapahoe and Laramie Formations that underlie the hillsides Most of the above lithologies encountered in boreholes contain some (less than 15 percent) gravel and cobbles scattered throughout the material as described on the lithologic logs (Appendixes C2 and C3) This coarse-size material, where present, is derived from the Rocky Flats and High Terrace alluviums Less frequently encountered lithologies include clayey sand gravelly clay (greater than 20 percent gravel) and clayey gravel

Colluvium along and onlapping the base of the RFA is typically coarser than the colluvium located further downslope, reflecting different source materials Colluvium typically lacks any apparent bedding structures and is poorly sorted, reflecting its deposition by gravity and absence of sorting by running water

Caliche is common throughout the deposit, occurring as thin layers discrete nodules or is disseminated Carbonaceous matter is also common in the near-surface portions of the deposit The deposit is usually highly oxidized, which is evident by mottled colors of brown, yellow brown and grayish orange Where the deposit is not highly oxidized gray and olive gray colors probably reflect the original color of the parent bedrock material Boreholes and monitoring wells that penetrated colluvium in the OU6 area are listed in Table 3 5-8 Lithologic variations within the colluvium deposits are shown on the lithologic logs (Appendixes C2 and C3) for the boreholes and wells listed on Table 3 5-8

The thickness of the colluvium in the OU6 area ranges from 1 8 feet to 10 feet The thickness of the colluvium is controlled, in large part, by the shape of the underlying bedrock surface In areas of bedrock erosional lows occurring along the slopes, the colluvium is thicker In areas where the bedrock surface occurs as a ridge, the colluvium is thinner

3.5 1 5 Landslides

During the OU6 Phase I field investigation, a number of landslides were identified and mapped in the OU6 area (see Plate 3 5-2) Several landslides are located on the north hillside, adjacent to South Walnut Creek and on the south hillsides of North Walnut Creek and the unnamed tributary These landslides exhibit evidence of mass movement of surface soil and possibly bedrock materials along relatively distinct curved slip surfaces Areas of hummocky topography reflect downslope creep of surface soils with no observable headward scarp

Due to the absence of subsurface control, the extent of bedrock involvement is unknown. Detachment scarps are usually developed along the head areas of landslide features Within the OU6 area, some landslides exhibit multiple scarps suggesting sequential movement, while other landslides show relatively fresh (non-vegetated and moist) scarp faces suggesting recent movement Vertical displacement along these scarps was observed to be from approximately one to four feet

Landslides on the south hillside of South Walnut Creek are usually located downslope from the alluvial or bedrock groundwater discharge areas The discharge of groundwater increases the water saturation within downslope soils which, in turn, leads to shear failure of the material Some landslides on the north hillside of North Walnut Creek are also located downslope from groundwater discharge areas, while other landslide features occur at lower elevations near the creek

3.5 1 6 Man-made Deposits

Man-made deposits or artificial fill within the OU6 area, were identified using information from historical reports, aerial photographs of the OU6 area for the years 1964, 1971, 1978, 1980, and 1986 field mapping of deposits during January 1994, and a geophysical EM-31 survey conducted in the Fall 1992 (Section 2 2 6) Several areas in OU6 within and outside of IHSS boundaries have fill material Disturbed ground within OU6 consists of areas where surface soils have been removed, graded or otherwise disturbed during construction or interim remedial activities Three general categories of man-made deposits have been identified reworked soil, debris dumps and imported fill The locations of these deposits within OU6 IHSSs are shown on Plate 3 5-2 Specific areas of man-made deposits are discussed in Section 3 9 Other areas outside the boundaries of OU6 IHSSs that have had soil removed have been graded or are otherwise disturbed are shown in Plate 3 5-2

Material used in the construction of the dams for the A and B-Series Ponds consists of aggregate and soil (DOE 1992b) Figures 3 5-8 and 3 5-9 (cross sections along North and South Walnut Creek drainages) illustrate locations and apparent construction material of the dams Discussion of the construction of the dams for the A and B-Series Ponds is found in Sections 3 9 2 2 and 3 9 3 2

Boreholes and monitoring wells that penetrated man-made deposits in the OU6 area are listed in Table 3 5-9 Lithologic variations within the man-made deposits are shown on the lithologic logs (Appendixes C2 and C3) for the boreholes and wells listed on Table 3 5-9

3 5 2 Bedrock Geology

Shallow bedrock geologic units within OU6 consist of Cretaceous age claystones, siltstones, and sandstones of the Arapahoe Formation and the upper portion of the Laramie Formation Scattered outcrops are exposed as a result of stream incision along the North Walnut Creek South Walnut Creek and the unnamed tributary drainages (Plate 3 5-2) The Arapahoe and Laramie bedrock units underlie the unconsolidated surface deposits encountered in OU6 (Figures 3 5-7 through 3 5-9)

The current stratigraphic classification of the sandstones encountered at RFETS is based on depositional environment determination and age-dating criteria Therefore, sandstones, when present in the bedrock sequence, were used to clarify the contact between the Arapahoe and Laramie Formations Previous investigations have proposed differing geologic ages for bedrock units within the OU6 study area These past nomenclatures and age assignments are briefly discussed here along with the bedrock designations used in this report in order to clarify the current interpretation

The 1991 Geologic Characterization Report (DOE 1991d) defined at least five mappable sandstone intervals within the shallow bedrock beneath RFETS This report designated these intervals as Sandstones No 1 through No 5, with Sandstone No 1 being the shallowest interval and Sandstone No 5 being the deepest The sandstones were described as lenticular in geometry and discontinuous The base of the Upper Cretaceous age Arapahoe Formation was tentatively placed at the bottom of the No 5 Sandstone This designation made the Arapahoe Formation approximately 150 feet thick in the central portion of RFETS

The 1992 Phase II Geological Characterization Report (DOE 1992c) was intended to "resolve inconsistencies among previously published geologic maps with regard to stratigraphic and structural interpretations " This report defined the Arapahoe/Laramie contact at the base of the No 1 Sandstone based on the study of measured sections, geologic mapping, and sedimentary petrology Specifically, the report designates the base of the Arapahoe Formation as the base of a coarse sandstone with chert pebble conglomerate in the Golden area (DOE 1992c) This revised contact designation results in an estimated Arapahoe Formation thickness of 15 to 25 feet in the central portion of RFETS Discussion of bedrock geology in the OU6 Phase I report will use this revised contact between the Arapahoe and Laramie Formations, as designated in the 1992 report (DOE 1992c)

Additionally, in 1992, a palynologic study of bedrock core samples from the RFETS site was undertaken (DOE 1993c) The study analyzed spores, pollen, dinoflagellates, and acritarchs (marine plankton) collected from the bedrock materials for determination of age and environments of deposition This study has tentatively age-dated the geologic units directly beneath the No 1 Sandstone as lower to middle Maastrichtien in age (i e , part of the Laramie Formation) Analysis of samples collected from the No 1 Sandstone, adjacent, and overlying claystone units did not yield definitive age dates for these units These study results tend to support the revised (DOE 1992c) Arapahoe/Laramie contact designation The study results also indicate a fluvial environment for the Arapahoe No 1 Sandstone and a shallow marine or brackish marine water depositional environment for the Laramie sandstones (No 2 through No 5) The base of the Arapahoe Formation is considered to be the No 1 Sandstone with the underlying claystones and siltstones designated as Laramie Formation

In this report, sandstones encountered in outcrop and drill core collected during the OU6 Phase I investigation are classified as either Arapahoe No 1 Sandstone or as Laramie formation sandstones based on lithologic characteristics and the dip projection of top of bedrock elevations (approximately 1 5 degrees east) of Arapahoe No 1 Sandstone from nearby areas Where the Arapahoe No 1 Sandstone was not encountered, no formation designation was assigned to claystones or siltstones due to the difficulty in determining the age of the units (DOE 1993c) Discussions of sandstone bedrock encountered in specific IHSSs are included in Section 3 9

3 5 2 1 Claystones, Siltstones and Sandstones

Within the OU6 area, claystones, siltstones, and sandstones constitute the major bedrock lithologies Claystones are predominant and consist of varying degrees of sandy/silty claystones and claystones with minor sand and silt (<20 percent) Claystones subcrop within 30 feet of the surface in the OU6 area and vary from unweathered (gray to olive-gray) to extremely weathered (yellow and yellow-orange) strata with iron-stained and caliche-filled fractures Siltstones occur less frequently and consist of clayey siltstones and siltstones with less than 20 percent sand and/or clay The siltstones vary from unweathered (gray to olive-gray) to extremely weathered (yellow and yellow-orange) strata Boreholes and monitoring wells that penetrated Upper Cretaceous claystone and/or siltstone in the OU6 area are listed on Table 3 5-10 Lithologic variations within the Cretaceous claystone/siltstone interval are shown on the lithologic logs (Appendixes C2 and C3) for the boreholes and wells listed on Table 3 5-10

Previously mentioned site-wide studies (DOE 1991d, DOE 1992c and DOE 1993c) state that the Arapahoe No 1 Sandstone was deposited in a fluvial environment as channel sands, point bars and overbank deposits The No 1 Sandstone is predominantly a clayey sandstone, fine- to medium-grained, well sorted, moderately to highly weathered (yellow and yellow-orange), with a sharp contact occurring between this sandstone and underlying claystones

Outcrops of the No 1 Sandstone and the OU6 borings and monitoring wells which encountered the No 1 Sandstone are shown on Plate 3 5-3 The No 1 Sandstone outcrops occur along the roadcut within the western portion of IHSS 156 2 on the northern and southern hillsides below IHSS 216 1 and on the interfluve between North Walnut and South Walnut Creeks east of IHSS 216 1 The top of the No 1 Sandstone occurs at an approximate elevation of 5 910 feet in an outcrop north of IHSS 216 1 (Plate 3 5-2) In an outcrop south of IHSS 216 1 (Plate 3 5-2), the base of the No 1 Sandstone occurs at an approximate elevation of 5,860 feet

Borings and monitoring wells drilled or installed within OU6 IHSSs 165, 156 2, and 216 1 (Plate 3 5-3) encountered the No 1 Sandstone in localized areas, thus revealing an incomplete picture of the extent of this sandstone The top of the No 1 Sandstone was encountered in borings and wells at elevations ranging from 5,946 feet to 5,937 feet MSL, which correlates to the No 1 Sandstone elevations encountered in OU2 and OU4 This correlation is supported by textural characteristics and the similarity of the sharp contact between the No 1 Sandstone and underlying claystones observed within OU2 (DOE 1993d) and OU6 No boreholes penetrated the entire No 1 Sandstone interval within the OU6 area, thus the total thickness of this sandstone unit is unknown However, the No 1 Sandstone in the OU2 area was up to 48 feet thick (DOE 1993d) Further discussion of correlations for the Arapahoe No 1 Sandstone are presented in Section 3 9

Boreholes and monitoring wells that penetrated Arapahoe No 1 Sandstone in the OU6 area are listed on Table 3 5-11 Lithologic variations within the Arapahoe No 1 Sandstone are shown on the lithologic logs (Appendixes C2 and C3) for the boreholes and wells listed on Table 3 5-11

Sandstones encountered at stratigraphically lower elevations than the No 1 Sandstone, are considered to be part of the Laramie Formation Limited information is available (based on current subsurface control in the OU6 area) to evaluate the geometries and lateral continuity of the upper Laramie sandstones, therefore, no correlations were made for upper Laramie sandstones in this report The upper Laramie Formation, based on previous studies (DOE 1991d DOE 1992c) consists predominantly of claystones and siltstones which directly underlie either the No 1 Sandstone or the surface deposits in the OU6 area Correlations between facies cannot be determined based on the distances between outcrops and locations of boring and monitoring well logs (hundreds of feet) Locations of borings/monitoring wells that encountered the Laramie Formation and Laramie Formation outcrops are shown on Plate 3 5-3

3 5 2 2 Top of Bedrock Surface

The top of bedrock surface within RFETS influences groundwater flow and consequently contaminant migration pathways The bedrock geology, especially the top of bedrock surface was characterized using available data from the OU6 Phase I field investigation, historical data and ongoing investigations (Tables 3 5-1 and 3 5-2) Plate 3 5-3 shows the relief on top of the bedrock surface underlying the surface deposits

Subsurface borehole control within the OU6 area is limited and is primarily found in OU6 IHSSs where bedrock was encountered during the field investigation The geometry of the No 1 Sandstone and the bedrock surface are discussed in detail in Section 3 9 for each IHSS Findings from the OU2 (DOE 1993d) and OU4 (DOE 1994f) RFI/RI Reports concerning the No 1 Sandstone and the bedrock surface were incorporated, when appropriate, into the IHSS-specific discussions (Section 3 9)

3 6 HYDROGEOLOGY

3 6 1 Regional Hydrogeology

The Denver Groundwater Basin underlies a 6,700-square-mile area in Colorado, extending from the Front Range on the west to near Limon on the east and from Greeley on the north to Colorado Springs on the south The center of the basin is located south of Bennett Colorado, in western Arapahoe and Elbert Counties Alluvial aquifers, 20 feet to 100 feet in thickness, commonly occur in the valleys of large streams in the basin

The four major bedrock aquifers occurring in the Denver Basin from deepest to shallowest are the Laramie-Fox Hills Aquifer the Arapahoe Aquifer the Denver Aquifer and the Dawson Aquifer The Pierre Shale underlies these units and, due to its great thickness (up to 8 000 feet) and low permeability (Robson et al 1981a and 1981b) is considered to be the base of the four bedrock aquifers listed above Descriptions of the Denver Basin bedrock aquifers that exist beneath RFETS the Laramie-Fox Hills Aquifer and the Arapahoe Aquifer, are presented below The Denver and Dawson Aquifers do not underlie RFETS

Laramie-Fox Hills Aquifer

The Laramie-Fox Hills Aquifer is composed of the sandstone and siltstone units of the Fox Hills Formation and the lower sandstone units of the Laramie Formation (Figure 3 5-3) The thickness of the aquifer ranges from 200 to 300 feet near the center of the Denver Basin (Robson et al 1981b) RFETS is located near the western boundary of the aquifer The base of the aquifer dips steeply to the east in the area west of RFETS and then 2 to 3 degrees to the east beneath the site The upper Laramie Formation, which separates the unconsolidated, Quaternary water-bearing units in OU6 (Section 3 6 2) from the underlying Laramie-Fox Hills Aquifer, consists of several hundred feet of claystones, siltstones, and some clayey or silty sandstones with occasional coal layers (DOE 1992c)

In outcrop and shallow subcrop areas, recharge to the Laramie-Fox Hills Aquifer occurs as infiltration of incident precipitation and as infiltration of groundwater from shallow alluvial aquifers respectively Outcrops of the Laramie and Fox Hills Formations, in clay pits west of RFETS, are believed to be recharge areas for the aquifer (Rockwell 1987b) Toward the interior of the basin downward leakage may also occur through the upper Laramie Formation from the overlying Arapahoe aquifer (Robson et al 1981b) Recharge to the Laramie-Fox Hills Aquifer from vertical leakage through the upper Laramie is expected to be minimal at RFETS due to the substantial thickness of claystones and siltstones of the upper Laramie Formation

On a regional scale groundwater in the Laramie-Fox Hills Aquifer flows from outcrop recharge areas toward the center of the basin In the vicinity of RFETS, groundwater flow is generally from west to east (Hurr 1976)

Arapahoe Aquifer

In the central part of the Denver groundwater basin, the Arapahoe Formation consists of a 400 to 700 foot-thick sequence of interbedded claystones, siltstones, sandstones, and conglomerates, with claystones and shale being more prominent in the northern third of the basin (Robson et al 1981a) Individual sandstone beds are commonly lenticular and range from a few inches to 30 to 40 feet in thickness (Robson et al 1981a) Beneath RFETS, the majority of groundwater flow in the Arapahoe Formation occurs in the lenticular sandstones within the claystones The portion of Arapahoe Aquifer present beneath RFETS at OU6 is not significant from a regional aquifer perspective because it is truncated by drainages on RFETS and does not extend laterally from RFETS to offsite areas

Recharge to the Arapahoe Aquifer occurs by the same mechanisms described for the Laramie-Fox Hills Aquifer In outcrop and subcrop areas recharge occurs from infiltration of incident precipitation and as infiltration of groundwater from shallow alluvial aquifers respectively At RFETS the Arapahoe Formation sandstones are recharged from infiltration of groundwater from overlying unconsolidated surface deposits On a regional scale, the primary recharge mechanism for the Arapahoe Aquifer occurs through leakage from the overlying Denver Aquifer (Robson et al 1981a)

Groundwater in the Arapahoe Aquifer flows from recharge areas at the edge of the basin toward discharge areas along incised stream valleys Groundwater also discharges from pumping wells (Robson et al 1981a)

3 6 2 OU6 Hydrogeology

Saturated, unconsolidated surface deposits and weathered bedrock units of the Arapahoe and/or upper Laramie Formations (Figure 3 5-3) are considered the hydrogeologic units of concern for the OU6 Phase I RFI/RI because of the potential for contamination and contaminant migration in these units Contaminant concentrations in the unweathered upper Laramie Formation at RFETS are typically low and the Laramie-Fox Hills Aquifer exists at a substantial depth below RFETS with a substantial thickness of unweathered intervening claystones and siltstones separating it from the shallow units (DOE 1992c) Therefore, the upper Laramie Formation and the Laramie-Fox Hills Aquifer are not addressed in the context of OU6 hydrogeology because the potential for contamination of these units from site-related activities appears to be minimal

Hydrogeologic conditions in the shallow geologic units at OU6 are influenced by local conditions local recharge, and interactions with South Walnut Creek, North Walnut Creek and the unnamed tributary of North Walnut Creek The earthen dams in both North Walnut Creek and South Walnut Creek also influence groundwater flow In general groundwater in the shallow unconsolidated geologic units of OU6 flows from topographically higher areas (mesas) toward the drainages (creeks) that divide the mesas Groundwater is then transmitted into and through the Valley-Fill Alluvium that underlies the creeks, ultimately discharging to the creeks The shape of the top of bedrock surface strongly influences groundwater flow by concentrating flow within erosional lows on the bedrock surface Groundwater recharge to the shallow unconsolidated units (Section 3 6 2 1 2) occurs primarily as a result of local infiltration of snowmelt, rainfall, and surface water within the OU6 area. Groundwater recharge also occurs as inflow to OU6 from upgradient areas to the west and from OU2 to the south

3 6 2 1 Upper Hydrostratigraphic Unit

The shallow, saturated hydrogeologic units at OU6 comprise the upper hydrostratigraphic unit (UHSU), which consists of unconsolidated surface deposits (RFA, Valley-Fill Alluvium, colluvium) and weathered claystones of the Arapahoe and/or Laramie Formations that are in hydraulic communication with the saturated surface materials The Arapahoe No 1 Sandstone and/or Laramie sandstones, where they appear to be in hydraulic communication with saturated surface materials, are also considered to be part of the UHSU The UHSU within OU6 is believed to exist predominantly under unconfined conditions, however, partially confining conditions may exist in the bedrock sandstones that are part of the UHSU

Groundwater level data used for the evaluation of the UHSU were collected from historical and Phase I monitoring wells within the OU6 area, as part of the Rocky Flats Groundwater Monitoring Program These data were obtained from RFEDS and are presented in Appendix C5

Groundwater level data were used to create UHSU groundwater hydrographs (Appendix C6), the UHSU potentiometric map (Figure 3 6-1), and the saturated thickness map of surface materials (Figure 3 6-2) The potentiometric surface and saturated thickness maps were prepared using all available groundwater elevation data from April 1993 (Table 3 6-1) and pond water elevation data measured April 2, 1993 (Figure 3 6-1) Physical parameter data, used for the evaluation of the hydraulic properties of the UHSU, were obtained from historical aquifer test results (Table 3 6-2) Descriptions of alluvial and bedrock materials were obtained from lithologic logs (Appendixes C2 and C3)

Many OU6 historical wells were considered to be screened in hydrostratigraphic units beneath the UHSU known as the Lower Hydrostratigraphic Unit (LHSU) The LHSU underlies the UHSU and is composed of unweathered upper Laramie Formation clayey-silty sandstones, claystones and siltstones The lithologic units of LHSU exhibit low permeabilities relative to the UHSU (EG&G 1991b) and are not considered to be in substantial hydraulic communication with the UHSU

Because the scope of the hydrogeologic evaluation included only the UHSU, it was necessary to distinguish between wells screened in the UHSU and wells screened in the LHSU To distinguish between the UHSU and LHSU wells were evaluated in terms of the lithologies of the screened interval, groundwater elevations, top of bedrock elevations encountered, thickness of weathered bedrock, and groundwater geochemistry (Section 3 6 2 2) Wells screened in unconsolidated surface materials and bedrock wells with geochemical data indicating the likelihood of hydraulic communication with saturated surface materials were considered to be UHSU wells Table 3 6-1 presents the UHSU and LHSU designation for each well listed and the criteria used to determine the UHSU/LHSU designation

3 6 2 1 1 Groundwater Flow Conditions

Valley-Fill Alluvium

Flow in the Valley-Fill Alluvium dominates the UHSU groundwater system in OU6 Valley-Fill Alluvium was deposited in the erosional lows along the bedrock surface underling the surface drainages of OU6 (North Walnut and South Walnut Creeks and the unnamed tributary of Walnut Creek) The erosional bedrock surface lows mimic the topography of the overlying surface drainages (Plate 3 5-3), which generally trend to the northeast in OU6 Groundwater in the RFA and colluvium flows into and is transported along flow pathways to the east-northeast in the Valley-Fill Alluvium (Figure 3 6-1) The approximate average horizontal hydraulic gradient in the saturated Valley-Fill Alluvium is 0 035 feet/foot

The saturated extent of Valley-Fill Alluvium measured perpendicular to the direction of flow, ranges from approximately 200 feet to 500 feet The maximum observed saturated thickness of the Valley-Fill Alluvium measured in April 1993 was 12 6 feet at well 1986 located southwest of IHSS 143 (Figure 3 6-2) Typically, the saturated thickness of alluvium in the

OU6 drainages ranges from approximately 5 feet to 10 feet in the deepest part of the bedrock surface lows It is unknown whether the alluvium is continuously saturated between the dams in the North Walnut Creek and South Walnut Creek drainages The potentiometric surface of saturated materials in these drainages is based on limited well information and measured water surface elevations The line indicating zero saturated thickness of surface materials, shown in Figures 3 6-1 and 3 6-2, was established by connecting points where potentiometric surface contours and top of bedrock elevation contours intersect

Rocky Flats Alluvium

The RFA is present in areas north and south of the current landfill, and on top of the mesas between the drainages (Plate 3 5-2) Groundwater occurrences in RFA are limited in the OU6 area Groundwater flow in saturated portions of the RFA is generally to the northeast, with a horizontal hydraulic gradient of approximately 0 03 feet/foot, following the topographic trend of mesas capped by this lithologic unit The maximum observed saturated thickness of RFA, measured in April 1993, was 10 2 feet at well 7187 located south of IHSS 167 1 (Figure 3 6-2) Groundwater flow in the vicinity of this well is generally to the east, discharging to colluvium and then into the Valley-Fill Alluvium within the unnamed tributary drainage

Historical and OU6 monitoring well water level data (Table 3 6-1 and Figure 3 6-1) show that much of the RFA is unsaturated, although the extent of saturated RFA is not well defined Well data indicate that the RFA is unsaturated in the upgradient (western) areas of the mesas that separate the Walnut Creek tributaries However, areal recharge due to precipitation may provide adequate recharge to saturate the RFA in some areas of the mesas during certain time periods of the year

Groundwater seepage from RFA potentially occurs where saturated RFA and bedrock are in contact along the slopes of the mesas In the OU6 area, groundwater seepage occurs in limited areas, as shown on Plate 3 5-2 RFA seeps are evident in several small northern tributaries to the unnamed tributary Another RFA seep is evident in a small drainage north of IHSS 165 and outside of the PA Seepage from the RFA appears to discharge to colluvium before discharging to the ground surface in these areas Seepage of groundwater originating in OU2 is shown along the southeastern slope of the South Walnut Creek drainage The absence of seeps along the slopes of the mesas that separate the OU6 drainages suggests that the degree of saturation of RFA in these areas is limited OU6 alluvial seep locations and associated downslope vegetation areas were mapped by visual field observation in Fall 1993 This seep-related vegetation typically consists of cattails baltic rushes, woody bushes, and other phreatophytes

Colluvium

Colluvium consisting of generally fine-grained soils (silt and clay) and some gravel covers the hillsides of OU6 In these areas, the potentiometric surface exists below the top of bedrock, and UHSU groundwater flow occurs only in weathered bedrock that underlies unsaturated surface materials Groundwater flow in weathered claystone occurs in the vicinity of wells 3086 (north of the Solar Evaporation Ponds), B206689 (north of IHSS 166 3), and B206889 (southeast of Landfill Pond) (Figure 3 6-1)

Weathered UHSU Bedrock Units (Arapahoe and Laramie Formations)

The UHSU includes saturated weathered and/or fractured claystones and sandstones of the Arapahoe and Laramie Formations which subcrop beneath and/or are in hydraulic communication with saturated alluvium or colluvium Wells B206189 (landfill area west of OU6) and P219589 (southeast of the Solar Evaporation Ponds) are screened in weathered claystones that subcrop beneath saturated alluvial materials Groundwater elevations in these wells indicate that the claystones are hydraulically connected to the saturated alluvial materials (Figure 3 6-1)

Well 76292 (within IHSS 165) and wells P208989 and P209489 (north of Solar Evaporation Ponds) (Figure 3 6-1) are screened in weathered bedrock Groundwater elevations in these wells indicate that the groundwater flow direction is generally to the north in this area The interceptor trench system (also known as the french drain), located north of these wells (Figure 3 6-1) was constructed to collect shallow groundwater flowing from the Solar Evaporation Ponds area and was installed at the approximate top of bedrock

A subcropping Laramie sandstone was encountered beneath the saturated alluvium found in well 1186 (east of Pond A-4 Figure 3 6-1) Although well 1186 is screened in alluvium it is expected that the Laramie sandstone in direct contact with the alluvium is also hydraulically connected to the alluvial unit at this location and may be locally part of the UHSU

3 6 2 1 2 **Recharge** Areal groundwater recharge to the UHSU occurs from direct infiltration of local precipitation, and by seepage from surface water features such as ponds, creeks, and ditches The rate of areal recharge is generally highest during the late winter and spring seasons when precipitation is high and evapotranspiration is low The effects of increased temperature and higher evapotranspiration in summer months tend to minimize the recharge rate during summer Recharge is also minimal during fall and early winter months, due to the low precipitation that occurs during those months The net annual groundwater recharge rate resulting from infiltration of precipitation ranges from 1 0 inch to 1 3 inches per year (DOE 1993d) This is approximately 7 to 9 percent of the average annual precipitation of 15 inches per year received at RFETS

Seasonal areal recharge effects on the OU6 UHSU groundwater system are indicated by the fluctuations in groundwater elevations that occur in response to seasonal precipitation Alluvial groundwater levels typically rise in the spring, due to recharge and then decrease during summer and winter months until spring of the following year when the seasonal cycle begins again Hydrographs for alluvial wells 1386, 2886, 3586, 3786, 7287, and P207889 (Appendix C6) illustrate these seasonal groundwater level fluctuations Water level changes due to recharge were as great as 5 feet (well 2886) during the period March 1992 to April 1992, a two-month period during which approximately 3 inches of precipitation was recorded at RFETS

Surface water from the A and B-Series Ponds, located in the North Walnut Creek and South Walnut Creek drainages, respectively, infiltrates the subsurface units and provides another source of groundwater recharge within OU6 The unnamed tributary, North Walnut Creek, and South Walnut Creek also recharge groundwater to OU6 due to infiltration of surface water especially significant during precipitation events

Groundwater inflow across upgradient boundaries of OU6 also provide potentially significant sources of recharge to the UHSU Groundwater flow directions and hydraulic gradients observed in April 1993 (Figure 3 6-1) indicate flow into OU6 from the present Landfill

(IHSS 114) and from upgradient areas in the South Walnut Creek drainage The potentiometric surface in the Landfill area indicates that there are two principal potential components of groundwater flow (1) flow to the east and northeast along the unnamed tributary drainage, and (2) flow to the southeast where groundwater flows toward the South Walnut Creek drainage The flow component to the southeast from the Landfill area is not well defined however it does appear to be a source of groundwater recharge to OU6

Groundwater flow to the east and northeast occurs in the area of the Old Outfall (IHSS 143), located west of the OU4 french drain, installed in saturated surface materials Another source of OU6 groundwater recharge is discharge from bedrock and alluvial seeps along the south slope of South Walnut Creek drainage (Figure 3 6-1) Seepage discharge from these lithologic units flows into the colluvium on the hillside and flows downhill, discharging to the Valley-Fill Alluvium in the drainage or the flow may discharge from the colluvium onto the surface and be evapotranspirated

3 6 2 1.3 <u>Hydraulic Properties and Estimated Groundwater Flow Velocities</u> Estimates of hydraulic conductivity for the UHSU within OU6 are based on aquifer tests (drawdown-recovery packer and slug tests) conducted on wells installed in 1986 and 1987 Hydraulic conductivities screened interval lithologies and data sources for the tested wells are summarized in Table 3 6-2

<u>Valley Fill Alluvium</u>

Hydraulic conductivity data were available for three wells screened in Valley-Fill Alluvium, wells 1586 1786 and 3586 where the estimated values were 4 3E-05 centimeters per second (cm/sec) 4 8E-06 cm/sec and 1 4E-04 cm/sec respectively The lithologic description of the screened intervals at wells 1586 and 1786 indicate the material may be finer-grained than the material described for the screened interval at well 3586 The geometric mean of these three results is 3 1E-05 cm/sec The average groundwater flow velocity (average linear velocity) for the Valley-Fill Alluvium was estimated to be about 10 feet/year, based on the geometric mean hydraulic conductivity, the estimated average hydraulic gradient for Valley-Fill Alluvium (0 035 feet/foot) and an assumed effective porosity of 10 percent

Rocky Flats Alluvium

Hydraulic conductivity values for the RFA, based on results from aquifer tests at eight wells, ranged from 6 4E-05 to 1 3E-03 cm/sec (Table 3 6-2) The geometric mean of the results is 5 0E-04 cm/sec The average groundwater flow velocity for the RFA was estimated to be about 150 feet/year, based on the geometric mean hydraulic conductivity, the estimated average hydraulic gradient (0 03 feet/foot), and an assumed effective porosity of 10 percent

Weathered UHSU Bedrock Units (Arapahoe and Laramie Formations)

One hydraulic conductivity value reported at 8 6E-07 cm/sec for the weathered Arapahoe/Laramie Formation claystone was obtained for well 3086 This well was screened from approximately 2 5 feet to 15 feet in bedrock No aquifer testing data for weathered UHSU sandstone were available for OU6 Calculated values of hydraulic conductivity for the Arapahoe No.1 Sandstone from pumping test measurements performed in OU2 ranged from 3 7×10^{-4} cm/sec to 6 2×10^{-4} cm/sec (DOE 1993d) The Arapahoe No 1 Sandstone is not extensive in OU6 (Section 3 5 2 1) therefore, the hydraulic conductivity value for the claystone at well 3086 may be more representative of conditions in weathered bedrock within OU6 Groundwater velocity was not estimated for weathered bedrock due to a lack of data However, based on relative hydraulic conductivities, the velocity is expected to be substantially lower than that of RFA and Valley-Fill Alluvium

3 6.2 2 Groundwater Geochemistry

The groundwater geochemistry of the UHSU in RFETS background areas and in OU6 was evaluated to determine (1) if it is appropriate to use RFETS background groundwater data for a comparison of inorganic concentrations in OU6 groundwater, and (2) which wells screened in weathered bedrock should be considered UHSU wells (Section 3 6 2 1)

3.6.2.2 1 Background Groundwater Geochemistry A detailed evaluation of groundwater geochemistry for RFETS background areas was presented in the Final Background Geochemical Characterization Report (DOE 1993e) Stiff diagrams were used in the evaluation to demonstrate variations in water type within UHSU groundwater and to distinguish UHSU groundwater from LHSU groundwater The diagrams are graphical depictions of water geochemistry in which dissolved concentrations of major cations (Na^+ K^+, Ca^{+2}, Mg^{+2}, and Fe^{+2}) and major anions (Cl, HCO_3 SO_4^{2} and CO_3^{2}) were expressed in milliequivalents per liter (meq/l) The width of a Stiff diagram is an approximation of the total ionic content and may be an indication of the residence time of groundwater in water bearing units An increasing ionic content or total dissolved solids (TDS) concentration is directly proportional to increased residence time (DOE 1992d) Well locations with narrow Stiff diagram patterns (low TDS) are likely receiving recharge from surface or near surface sources

Background groundwater within the UHSU (i e , Valley-Fill Alluvium, RFA, colluvium, and weathered claystones) and LHSU unweathered sandstone(s) is described in terms of Stiff diagram results in the following section The locations of background monitoring wells used in the Stiff diagram evaluation are shown on Figure 3 6-3 Groundwater from most of the UHSU background wells is a calcium-bicarbonate water with low TDS (Figures 3 6-4 through 3 6-7) There are a few exceptions in colluvial and weathered claystone wells The Stiff diagram results suggest that it is reasonable to group weathered claystones with the unconsolidated surface deposits into a single hydrostratigraphic unit that receives recharge from surface or near-surface sources (i e the UHSU) Groundwater in the LHSU background wells is similar to UHSU groundwater in terms of TDS but can be distinguished from UHSU groundwater on the basis of sodium (Na^+) and potassium (K^+) meq/l versus calcium (Ca^{+2}) meq/l (Figure 3 6-8) LHSU groundwater is typically higher in Na^+ and K^+ than in Ca^{+2} while UHSU groundwater is typically higher in Ca^{+2}

<u>Valley-Fill Alluvium</u>

Stiff diagrams from six Valley-Fill Alluvium wells (B102289, B102389 B202489, B202589, B302789 and B302889) located in the RFETS buffer zone, are shown on Figure 3 6-4 Groundwater from each of these wells is a calcium-bicarbonate type water The lowest ionic concentrations were found in wells B102289 and B102389, located northwest of the RFETS security area in the Rock Creek drainage and upgradient of wells B202489 and B202589 Wells B302789 and B302889 located in the southeastern buffer zone had the highest ionic content of the Valley-Fill Alluvium wells

Rocky Flats Alluvium

Stiff diagrams from eleven RFA wells (B200589, B200689, B200789, B200889, B400189, B400289, B400389, B400489, B405586, B405689, and B405789), distributed in the north and southwest part of the buffer zone, indicate that groundwater in the RFA is a calcium-bicarbonate-type water (Figure 3 6-5) Concentrations of the major cations and anions in these wells are generally low, suggesting the likelihood of short residence time for groundwater in this geologic unit Recharge to groundwater, due to infiltration of incident precipitation appears to be a significant factor in this geologic unit The background wells (B400389 and B405689) screened in RFA that contain the highest ionic content are located in the buffer zone southwest of the RFETS security area.

Colluvium

Stiff diagrams from wells B201189, B201289 B201589, and B205589 located in the north buffer zone and well B401989, located in the southwest buffer zone, represent colluvial groundwater (Figure 3 6-6) Groundwater in wells B201589 and B401989 appears to be a calcium-bicarbonate-type water with low levels of TDS Groundwater in well B201289 appears to be a calcium sodium potassium-sulfate-type water with significantly higher TDS concentrations indicating long residence time of groundwater at this well Wells B201189 and B205589 have similar ionic content, indicating sodium potassium calcium-bicarbonate-type water

Weathered Claystones (Arapahoe and Laramie Formations)

Stiff diagrams from wells B203189, B203289, B203489, B304889, B305389, and B405489, located in the buffer zone, are shown on Figure 3 6-7 Groundwater from background wells screened in weathered claystones of the Arapahoe or Laramie Formation is typically a calcium-bicarbonate water type with low ionic content Groundwater from well B304889 is an exception, it appears to be a sodium, potassium, calcium-sulfate, bicarbonate-type water with high ionic content The water type at B304889 is more typical of the LHSU than the UHSU (DOE 1993e) and it appears that the residence time of the sampled groundwater at this well is significantly greater than at other weathered claystone wells With the exception of well B304889 it seems appropriate to group these wells with the UHSU

Unweathered LHSU Sandstones

Stiff diagrams from wells B203789, B203889, B203989, B204189, B304289, B304989, B304289, and B402189 screened in unweathered LHSU sandstones are shown on Figure 3 6-8 Groundwater in wells B203789 B203889 and B203989 located in the north buffer zone, is a sodium/potassium-bicarbonate-type water with low TDS concentrations Well B204189 also located in the north buffer zone, has significantly higher TDS levels and has a sodium/potassium-sulfate water type Groundwater in well B304289, located in the south buffer zone, has relatively low TDS concentrations and appears to be a sodium/potassium-bicarbonate/chloride water type The Stiff diagram for well B304989, located in the southeast buffer zone indicates a sodium/potassium-chloride/bicarbonate water type with moderate TDS concentrations The wells described above show groundwater geochemical conditions typical of the LHSU

Two other wells B402189 and B405889 located in the southwest buffer zone, appear to be screened in a lithologic unit that may be part of the UHSU They show calcium-bicarbonate type water at fairly low TDS concentrations These wells were included however with the LHSU in the Background Geochemical Report (DOE 1993e)

3 6 2 2 2 **OU6 UHSU Groundwater Geochemistry** Evaluation of OU6 UHSU groundwater geochemistry involved assessing the pH and Stiff diagrams of groundwater in various OU6 wells The median groundwater pH value calculated from 679 field measurements at 70 locations was 7 3 These field measurements were made during the period beginning third quarter 1990 and ending fourth quarter 1993

Stiff diagrams for wells installed within OU6 (Figure 3 6-9) and neighboring OUs were prepared using analytical results from selected wells to characterize the inorganic chemistry of UHSU groundwater Supporting calculations for each of the Stiff diagrams are presented in Table 3 6-3

Stiff diagrams indicate that meq of Ca^{+2} were greater than meqs of Na^{+} plus K^{+} in all selected OU6 UHSU wells Boring logs from the OU6 Phase I investigation (Appendix C2) indicate that caliche is present often in abundance in surface geologic materials within OU6 Caliche is composed of calcium carbonate ($CaCO_3$) which when leached by infiltrating precipitation provides a source of Ca^{2+} and bicarbonate (HCO^{3}) ions to groundwater Discussions of Stiff diagram results for selected UHSU wells are presented below

Valley-Fill Alluvium

Stiff diagrams from Valley-Fill Alluvium wells 1386, 1586, and 4287, located in the north buffer zone, indicate a calcium-bicarbonate water type (Figure 3 6-9) The TDS concentrations in these wells are relatively low, suggesting that the Valley-Fill Alluvium in OU6 is recharged from surface or near-surface sources A Stiff diagram for well 1986, located in the southwest buffer zone and screened in Valley-Fill Alluvium, exhibits a sodium potassium-bicarbonate-type water In general, the Valley-Fill Alluvium wells in OU6 and background areas have similar water types and TDS concentrations

Rocky Flats Alluvium

Stiff diagrams for RFA wells 6487, 7187, and 7287, located in the north buffer zone, indicate the presence of calcium-bicarbonate-type water (Figure 3 6-9) The TDS concentrations for these wells are relatively low, as indicated by their narrow Stiff diagrams, suggesting that recharge to the RFA occurs from surface or near-surface sources of water

Weathered UHSU Bedrock Units (Arapahoe and Laramie Formations)

Stiff diagrams were used to distinguish UHSU weathered bedrock wells from wells screened in LHSU bedrock Well 76292, located in the eastern PA, and wells B206189, B206589, B206689 and B208789, located in the north buffer zone, exhibit the calcium-bicarbonate-type water typically found in wells screened in unconsolidated surface materials (Figure 3 6-9) This suggests that these wells are screened in weathered bedrock that is hydraulically connected to saturated surface materials Therefore, these wells are considered part of the UHSU

Unweathered LHSU Units

Wells 1486 (sandstone), 1686 (siltstone/claystone) B210389 (claystone) B207089 (claystone) and P210089 (claystone, siltstone) exhibit water types that are considered to be representative of the LHSU Each of these wells exhibit higher Na^+ and sulfate (SO_4^{2}) concentrations than UHSU wells The higher TDS concentrations shown for these wells indicated by the wider Stiff diagram patterns suggest that the screened lithologic units of these wells are not strongly influenced by surface or near-surface sources of recharge water Higher TDS concentrations also suggest that the residence time of groundwater in these units is longer than that of the UHSU

Comparison of OU6 and Background Groundwater Geochemistry

Stiff diagrams from background wells (Figures 3 6-4 through 3 6-8) indicate that the predominant UHSU water type in RFETS background area groundwater and OU6 area groundwater is calcium-bicarbonate Groundwater in the UHSU in both background and OU6 areas is strongly influenced by recharge from near-surface sources, and the residence time of groundwater in both areas is short Caliche found in unconsolidated surface materials at RFETS may be the source of calcium, a dominant component in the UHSU groundwater geochemistry in background and OU6 areas

The similarities between groundwater in the RFETS background and OU6 areas suggest that similar hydrogeologic conditions exist in the two areas Similarities between groundwater from both areas suggest it is appropriate to use RFETS background data for comparison with OU6 groundwater data in the selection of UHSU chemicals of concern for various metals and radionuclides

3 7 SURFACE WATER

RFETS lies within the drainage basins of Rock Creek and Big Dry Creek which are tributaries to the South Platte River Walnut Creek is a tributary to Big Dry Creek and drains approximately one-third of the RFETS site including most of the security area (Figure 3 7-1) The headwaters of Walnut Creek are approximately 1 5 miles west of RFETS near the foothills of the Colorado Front Range Only a small percentage of the Walnut Creek drainage area is west of RFETS due to the proximity of the Coal Creek drainage to the north and the Woman Creek drainage to the south Walnut Creek leaves RFETS at Indiana Street and is diverted around Great Western Reservoir by the Broomfield Diversion Ditch since Great Western Reservoir is used by the city of Broomfield as a drinking water supply

The OU6 IHSSs lie within the Walnut Creek drainage area, as shown on Figure 3 7-1 The four major tributaries to Walnut Creek are South Walnut Creek, North Walnut Creek, McKay Ditch, and an unnamed tributary, sometimes referred to as No Name Gulch (Figure 3 7-1)

3 7 1 Drainage Patterns of Walnut Creek and Its Tributaries

One of the predominant features of the Walnut Creek drainage area is the highly impervious nature of the RFETS security area (Section 3 7 4) Runoff from the security area flows to North Walnut Creek and South Walnut Creek which are intermittent streams that drain all but a small part of the RFETS security area (Figure 3 7-1) These creeks also receive runoff from the adjoining buffer zone South Walnut Creek originates near the center of the RFETS security area. Baseflow in the upper reaches of South Walnut Creek is due to discharges of building footer drains as well as flow from several seeps along the south bank of the creek. North Walnut Creek begins just east of the McKay Diversion Canal and flows along the northern boundary of the RFETS security area. The baseflow in North Walnut Creek is augmented by seeps and footer drains

The flow of North Walnut Creek is detained by the A-Series Ponds and the flow of South Walnut Creek is detained by the B-Series Ponds, shown on Figure 3 7-1 North Walnut Creek the unnamed tributary, and South Walnut Creek converge downstream of the ponds to form Walnut Creek At approximately 1,300 feet downstream of this convergence, the McKay Ditch flows into Walnut Creek Just upstream of the eastern RFETS boundary, Walnut Creek flows through the W&I Pond The history of this pond is discussed in Section 1 3 2 5 Walnut Creek flows to the Broomfield Diversion Ditch and around Great Western Reservoir, located approximately 0 3 miles east of the eastern boundary of RFETS

Some of the Walnut Creek surface water drainage area is not hydrologically associated with the RFETS security area or the A and B-Series Ponds The area west of the security area as well as much of the area north of the secunty area and south of the Rock Creek dramage are mcluded m the Walnut Creek dramage Surface runoff west of the RFETS secunty area is diverted around this area by the McKay Diversion Canal (sometimes called the West Diversion Ditch) and the McKay Bypass Canal (sometimes called the Walnut Creek Diversion Canal) which flow into McKay Ditch as shown on Figure 3 7-1 Surface runoff in the area north of the RFETS secunty area drains to McKay Ditch or the unnamed tributary both of which flow toward Walnut Creek Flow from the McKay Ditch or the unnamed tributary rarely reaches Walnut Creek due to infiltration and evaporation (EG&G 1994a)

3 7 2 Pond Operations

Operations of the A and B-Series Ponds along North Walnut Creek and South Walnut Creek respectively, are described herein Site descriptions and histories of IHSSs 142 1-9 are presented in Sections 1 3 2 3 and 1 3 2 4

All flow in the B-Series Pond system is eventually detained in terminal Pond B-5 Prior to September 1990, water in Pond B-5 was monitored for water quality before discharging to South Walnut Creek, in accordance with RFETS National Pollutant Discharge Elimination System (NPDES) permit Since September 1990, Pond B-5 water quality has been monitored and then pumped to terminal Pond A-4 in North Walnut Creek

Ponds B-1 and B-2 which are reserved for spill control and flood control are isolated from the rest of the B-Series detention pond system by a bypass that routes upstream flows to Pond B-4 Pond B-3 is used as a holding pond for sanitary STP effluent Flow from the STP to Pond B-3 is generally constant at approximately 150,000 gallons per day The normal discharge of Pond B-3 is to Pond B-4 on a daily basis during daytime hours For a short period of time in 1989, Pond B-3 water was pumped to a spray irrigation system at the East Spray Field Area (IHSS 216 1) (Figure 1 3-3) This temporary practice was discontinued because slow water evaporation resulted in high volumes of surface runoff

Ponds B-4 and B-5 receive surface water runoff from the central portion of the RFETS security area via a bypass line that diverts the runoff around Ponds B-1, B-2, and B-3 During large runoff or snowmelt events estimated to occur one or two times per year (EG&G 1994b) surface water runoff is routed to Pond B-5 through the Central Avenue Ditch

(Figure 3 7-1) During smaller events, Pond B-5 receives local runoff as well as flow-through drainage from Pond B-4

Between 1952 and 1979, Pond A-1 was used to hold laundry wastewater and other liquid waste discharged into North Walnut Creek from the northern production facilities, through the Old Outfall Area (IHSS 143) After the construction of Pond A-2 and prior to 1978, the water of Pond A-1 was released into Pond A-2 and disposed of by natural and spray evaporation Pond A-1 is presently used for spill-control management, and receives only local surface runoff and seepage that may occur in the area.

Prior to 1993 the water from Pond B-2 was pumped to Pond A-2 once per summer via an underground pipeline (Figure 1 3-3) Like Pond A-1, Pond A-2 is presently used for spill-control management, and receives only local surface runoff and seepage that may occur near this area Spray evaporation of water from both Ponds A-1 and A-2 was performed by spraying the water onto the pond surfaces and banks. Spray evaporation from Pond A-1 and Pond A-2 was discontinued in 1993 (EG&G 1995a)

Flow in North Walnut Creek, including surface water runoff from the northern production facilities is diverted around Ponds A-1 and A-2 and channelled into Pond A-3 via the A-1 Bypass (Figure 1 3-3) The water is temporarily detained in Pond A-3 before being released into Pond A-4

Historically, Pond A-4 received water from Pond A-3 only Presently, Pond A-4 receives water from Pond A-3 and water that is pumped from Pond B-5 The water in Pond A-4 is treated by a granular activated carbon (GAC) filtration system and screen filter before being discharged downstream into Walnut Creek, if needed to meet water quality standards for an NPDES permit

The W&I Pond (IHSS 142 12) is downstream of Pond A-4, located approximately 0 5-miles east of the confluence of North Walnut Creek and South Walnut Creek Discharge from the W&I Pond occurs when the capacity of the pond becomes high enough to flow out and downstream into Walnut Creek Because the W&I Pond is relatively small (actual capacity has not been measured by surveying), a relatively insignificant amount of water released from Pond A-4 is detained in the W&I Pond

3 7 3 Pond Capacity

Pond capacity data and total runoff volumes, in acre-feet (ac-ft), for terminal Ponds A-3 A-4 B-4 and B-5 are presented on Table 3 7-1 These terminal ponds receive storm runoff from the RFETS security area which is diverted around Ponds A-1, A-2, B-1, B-2 and B-3, through a system of bypass channels previously described in Section 3 7 2 As shown in Table 3 7-1 terminal Ponds A-3 A-4, B-4, and B-5 were designed to hold surface runoff from very large precipitation events

The A-Series Ponds are sufficiently large enough to hold estimated runoff from the 25-year and 100-year precipitation events These precipitation events refer to very large storms which only occur once in 25 (or 100) years Ponds B-4 and B-5 are not sufficiently large enough to hold runoff from a 100-year 10-day event, as evidenced by the runoff volume of 146 percent of the combined capacities of Ponds B-4 and B-5 Since releases from Pond B-5 are pumped to Pond A-4, it is appropriate to consider the combined capacities of Ponds A-3, A-4, B-4 and B-5 The total capacity of these terminal ponds is 212 ac-ft a volume sufficiently large to contain the 174 ac-ft of runoff from the 100-year 10-day event (Table 3 7-1) Relationships between pond volumes, surface area, and water levels (i e , stage/storage and stage/area functions) for the A and B-Series Ponds are presented in the Merrick Pond Survey (Merrick 1992)

Except in the case of an extreme precipitation event, pond levels and volumes are maintained well below capacity The volume of water in Pond A-4 during the summer of 1992 is presented on Figure 3 7-2 Total precipitation from June through September of 1992 was 6 2 inches, which is slightly below the average precipitation of 6 35 inches during these months according to RFEDs data During the summer of 1992 the peak volume of Pond A-4 was 65 ac-ft (65 percent of capacity) This volume was the highest recorded during the period May 1990 through December 1993 The lowest volume observed during the summer of 1992 was 15 3 ac-ft (15 3 percent of capacity) The average recorded volumes for June through September 1992 is 47 ac-ft (47 percent of capacity) The largest storm event recorded during this period was almost two inches of rain on August 24 1992 This storm event had very little impact on the volume of water in Pond A-4 (Figure 3 7-2)

The volume in Pond A-4 dropped dramatically during and after periods of releases (Figure 3 7-2) The two starting times of releases shown on Figure 3 7-2 are July 10 and September 4 each approximately three weeks after the Pond A-4 water level had stabilized following water quality monitoring Discharges from Pond A-4 ranged from 0 53 to 2 43 cubic feet per second (cfs) The largest discharge from Pond A-4 corresponds to a drawdown of approximately 1 7 feet per day Drawdowns are normally much lower, averaging one-foot per day or less (EG&G 1994b)

3 7 4 Runoff Characteristics and Historical Flows

The amount of surface water runoff at RFETS is related to the intensity and duration of the precipitation Precipitation events at RFETS tend to be high intensity, short duration (less than an hour) thunderstorms, or snow storms with snowmelts of longer duration Long duration storm events (including snowmelt runoff events) typically produce more runoff volume runoff hydrographs of longer duration, and hydrographs of smaller peaks than intense thunderstorms at RFETS

Walnut Creek basin soil and topographical characteristics, shown on Table 3 7-2, also influence the quantity and timing of runoff Most precipitation runoff is generated from impervious areas of RFETS such as roads, buildings, parking lots, and disturbed areas cleared of vegetation Infiltration into RFETS soils is generally rapid Table 3 7-2 shows an initial infiltration value of 3 75 inches per hour (in/hr) for the basin average Evaporation contributes to significant losses of precipitation as a result of the relatively high solar radiation levels that reach the ground surface

There is very little overland flow on pervious land segments, except in the cases of extreme events This can be illustrated by comparing unit runoff coefficients (runoff per unit surface area) for two gauging stations within OU6 (Table 3 7-3) Gauging Station 03 (GS03) is located just downstream of the W&I Pond (Figure 3 7-1), at a point in the watershed where the drainage area is 3 71 square mile (sq mi) and the area is predominantly pervious (Table 3 7-2) The area that drains to GS10, located east of the PA (Figure 3 7-1), is approximately 0 35 sq mi (the sum of areas for drainage sub-basins CSWAA and CSWAB shown on Figure 3 7-1) and is predominantly impervious Unit runoff coefficient values for GS03 and GS10 for 15 months between July 1991 and August 1993 are shown on

Table 3 7-3 Both stations (GS03 and GS10) have complete flow records for these months The data collected for some of the months prior to 1993 are not consistently accurate (EG&G 1995b) However the data are considered to be valid for this general comparison Despite the fact that the runoff volume at GS03 is typically much greater than at GS10, the monthly runoff coefficient values are generally larger for GS10 than for GS03 and, overall for this time period the sum of monthly runoff coefficients is approximately twice as large for GS10 than for GS03 The true runoff coefficients for GS10 are probably greater than the values in Table 3 7-3 since runoff from approximately half of the area that drains to GS10 is diverted around GS10 during very large runoff events The true runoff coefficients for GS03 are probably smaller than the values in Table 3 7-3 because a significant part of the flow through GS03 originates as STP effluent (approximately 4,500 00 gallons per month) The impervious areas of OU6 generate significantly more runoff per unit area than the watershed as a whole

The hydrologic and topographic characteristics of the Walnut Creek watershed vary considerably from west to east The majority of the western portion from the mouth of Coal Creek Canyon to approximately the center of RFETS (sub-basins WADIV1 WADIV2 and WA15 Figure 3 7-1) is a relatively flat area (2 percent slope) with few defined runoff channels highly infiltrative soils (6in/hr), little industrial development, and uniform vegetative cover Consequently the times of concentration for these drainage basins (i e , the time required for runoff from all portions of these sub-basins to reach Walnut Creek) are relatively long (about an hour) compared to other sub-basins at RFETS These relatively long concentration times may permit the loss of significant quantities of runoff to subsurface flow, thus the production of little overall surface runoff Any water originating in this area is diverted around the A and B-Series Ponds through the McKay Ditch and the Walnut Creek Diversion (Figure 3 7-1)

Farther to the east the central portion of the Walnut Creek watershed (sub-basins WA11, WA12 SWA1 SWA3 CSWAB CSWAA and CWAC Figure 3 7-1) contains low to moderately infiltrative soils, large impervious areas and is the best developed drainage of the watershed A significant portion of the PA drains to this basin with flow being heavily regulated and attenuated by man-made detention ponds and diversion structures As discussed previously most water originating in the developed area flows through North Walnut and South Walnut Creeks to the A and B-Series Ponds

The eastern portion of the Walnut Creek watershed (sub-basins WA1, WA2, and WA3; Figure 3 7-1) is characterized by moderately infiltrative soils and broader valleys, with approximately 5 percent side slopes and 2 percent channel slopes (EG&G 1992c) Water from this drainage flows eastward through GS03 and leaves RFETS at Indiana Street

Walnut Creek basin characteristics (Table 3 7-2) affect the distribution and magnitude of flows that occur throughout the watershed The locations of the gauging stations in OU6 are not suitable for assessing runoff from exclusively pervious land segments, thus it is difficult to quantitatively assess the volume of runoff from these areas The OU6 gauging station locations permit assessment of runoff from the following areas the security area, in which the runoff flows into Ponds A-3 and B-4 through the bypass canals (GS13 and GS10), flow from Pond A-3 to Pond A-4 (GS12); flow from Pond B-4 to Pond B-5 (GS09), flow out of Ponds A-4 and B-5 (GS11 and GS08), and offsite runoff at the W&I Pond (GS03) Transfers from Pond B-5 to Pond A-4 are recorded with a flow meter in the pipe

The magnitude of total monthly flows for GS13, GS11, GS10, and GS03, from July 1991 through September 1993, are shown on Figure 3 7-3 Particular stations which do not contain data for specific months represent missing or questionable data. Flows during the winter months are less accurate than those during the rest of the year because of ice-related problems (EG&G 1994c) The highest monthly flow volume recorded at GS13 and shown on Figure 3 7-3, was 24,000,000 gal In general, during months of high precipitation, GS13 recorded high volumes of flow This pattern is to be expected, since GS13 predominantly measures direct storm water runoff from impervious and pervious land segments, since GS13 is upstream of the ponds and does not receive a significant amount of process wastewater An exception to this pattern is when 3 inches of precipitation fell on August 24, 1992, and only a relatively small amount of flow was recorded (4,440,000 gal) A possible explanation is that the gauging equipment at GS13 greatly underestimated the flow (1 97 inches) resulting from the large August 1992 storm event RFETS stream flow gauging equipment, including a 6-inch Parshall flume and an ISCO Model 3230 bubbler, is less accurate when flows exceed 3 cfs (EG&G 1994c)

The highest flow volume recorded at GS10 (Figure 3 7-3) is 8,770,000 gal, recorded in March 1992 Like GS13, most of the flow volume recorded at this station is from storm water runoff High flow months generally correspond to months with high amounts of precipitation or snow melt Exceptions to this pattern (e g , May 1992 and August 1992) may occur since runoff from the security area during large storms is sometimes diverted around GS10 and into the Central Avenue Drainage Ditch for which there are no flow records Due to seepage of groundwater and discharges from footer drains both GS10 and GS13 almost always record some flow with recorded baseflows in both creeks ranging from less than 0 01 to 0 2 daily mean cfs These baseflows are a small percentage of the total volume of runoff at these two stations

The maximum flows recorded at GS11 and GS03 are 39,000,000 gal (April 1993) and 77,000 000 gal (March 1992), respectively, as shown on Figure 3 7-3 Flows from these gauging stations (GS11 and GS03), each located downstream of the ponds are very similar Flow at GS03 is typically somewhat less than flow at GS11, indicating that losses to infiltration and evaporation between the two stations are generally greater than contributions to flow from local surface water runoff For both GS03 and GS11, flow volumes during a particular month depend more on the schedule of releases from Pond A-4 than on the amount of precipitation during that month or preceding months Months without flow were recorded in the data sets for GS03 and GS11 between July 1991 and September 1993

3 8 ECOLOGY

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3 9 PHYSICAL CHARACTERISTICS OF EACH IHSS

The physical characteristics of each OU6 IHSS are described below Where appropriate, individual IHSSs of similar characteristics and locations are grouped together for the purpose of discussion

3 9 1 Sludge Dispersal Area (IHSS 141)

3 9 1 1 Site Description

The Sludge Dispersal Area (IHSS 141) is located in the South Walnut Creek drainage west of Pond B-1 (IHSS 142 5) This IHSS covers approximately 1 19 acres and contains ground surface elevations ranging from approximately 5,935 feet to 5,897 feet MSL (Figure 1 3-4) Ninety-five percent of IHSS 141 is located on the northern hillside of South Walnut Creek The buffer zone access road extends north-south across South Walnut Creek along a land bridge through IHSS 141 West of the access road, the hillside slopes to the south at approximately 40 degrees from horizontal East of the access road, the hillside slopes to the east and southeast The southeast corner of IHSS 141 is located on the southern hillside of South Walnut Creek which flows through this portion of the IHSS

The northwestern corner of IHSS 141 is occupied by the STP, which is located on level ground at approximately 5,933 feet MSL The waste-related activities and history of IHSS 141 are discussed in Section 1 3 2 1

3 9 1 2 Geology

The geologic characterization of IHSS 141 is primarily based on information obtained from the First Interim Report of Field Activities, Vadose Zone Monitoring Report (DOE 1993b) The geologic interpretation for this IHSS is supplemented by the surface geologic map (Plate 3 5-2) and subsurface information obtained from well 75992 installed during the OU6 Phase I investigation to a depth of 15 5 feet This well is located approximately 10 feet outside the southeast corner of IHSS 141

The Vadose Zone Monitoring project (DOE 1993b) included the drilling of six borings (AB-1 through AB-4 AB-3N and AB-4N) to characterize the geology beneath the north and south sludge drying beds, which are housed by two buildings Borings AB-1, AB-2, AB-3, and AB-4 are shown on Figure 3 9-1 Borings AB-3N and AB-4N are not shown on Figure 3.9-1, however these borings were drilled adjacent and parallel to borings AB-3 and AB-4, respectively The lithologic logs for these borings are presented in Appendix C3 5 Geologic cross section D-D' (Figure 3 9-2) illustrates the subsurface geology in the vicinity of the sludge drying beds

Artificial fill underlies the sludge drying beds in the northwestern corner of IHSS 141 The fill ranges in thickness from 7 feet to 8 5 feet beneath the southern drying beds and approximately 4 feet beneath the north drying beds (Figure 3 9-2) The artificial fill consists of gravelly clays, clayey sands, clays, gravelly sands, and sandy clays varying in color from yellow-browns to yellowish orange Within IHSS 141, artificial fill covers the northern hillside of South Walnut Creek (Plate 3 5-2) Artificial fill also covers the hillside south of the sludge drying bed structures, as well as across South Walnut Creek where a land-bridge embankment was placed for the buffer zone access road

The RFA and colluvium underlying the artificial fill is at least 4-feet thick beneath the north drying beds as measured in boring AB-1 As stated in the Vadose Monitoring Zone Report (DOE 1993b) colluvial material and claystone bedrock slopes to the south at approximately 40 degrees toward South Walnut Creek Valley-Fill Alluvium (depth unknown) covers the South Walnut Creek drainage south of the STP Well 75992, at the southeastern corner of IHSS 141 encountered ten feet of colluvium before encountering claystone bedrock

Claystone bedrock encountered in well 75992 is olive-gray to black in color with yellowish-orange staining near the alluvium/bedrock contact The stratigraphic contacts away from borings shown in Figure 3 9-2 are inferred due to the limited extent of drilling

3 9 1 3 Hydrogeology

UHSU groundwater flow in the IHSS 141 area occurs to the southeast in hillside colluvium deposits that underlie artificial fill (Figure 3 5-9) Groundwater discharges from colluvium to Valley-Fill Alluvium deposits underlying South Walnut Creek The flow direction in the Valley-Fill Alluvium is to the northeast, following the trend of the creek The IHSS is located on the north side of a zone of saturated surface materials (Figure 3 6-1) that follows South Walnut Creek and an erosional low in the top of the bedrock (Plate 3 5-3) that originates southeast of the Solar Evaporation Ponds The estimated thickness of saturated materials in the erosional low is 0 to 5 feet

3 9 1 4 Surface Water

Surface water runoff from IHSS 141 drains eastward toward South Walnut Creek and the B-Series Ponds (IHSSs 142 5-9) A drainage ditch crosses this IHSS in a north-south direction collecting runoff between two roadways then drains toward the B-Series Ponds This IHSS straddles drainage sub-basins SWA3 to the east and CSWAB to the west (Figure 3 7-1) Soils in sub-basin SWA3 have a low to moderate infiltration rate while sub-basin CSWAB has a moderately high infiltration rate (Table 3 9-1) The surface soil within the Sludge Dispersal Area is approximately 25 percent impervious Surface soil in IHSS 141 (0 to 34 inches) are predominantly gravelly clay, gravelly sand, and sandy clay Below 34 inches the soil is gravelly clay, claystone, and silty clay (DOE 1993b)

3 9.2 A-Series Ponds (IHSSs 142 1-142 4)

3 9 2 1 Site Description

North Walnut Creek is an east-northeast flowing stream that has incised the pediment and cut into predominantly Cretaceous claystone bedrock The drainage extends 1 4 miles west-east across the middle of the OU6 study area, at an approximate grade of 3 percent, ranging in elevation from 5,935 feet MSL in the west to 5,710 feet MSL in the east (Plate 3 5-2) The hillslopes along North Walnut Creek vary from approximately 6 7 degrees to 11 4 degrees from horizontal

The A-Series Ponds, constructed by placement of earthfill dams across North Walnut Creek, are Ponds A-1, A-2, A-3, and A-4 (IHSSs 142 1 through 142 4, Figure 1 3-5) These IHSSs occupy 15 2 acres collectively The largest to smallest are Pond A-3 (6 7 acres) Pond A-4 (4 6 acres), Pond A-2 (2 4 acres), and Pond A-1 (1 5 acres) Waste-related activities and histories of IHSSs 142 1 through 142 4 are discussed in Section 1 3 2 3 The OU6 Phase I field investigation within the North Walnut Creek drainage included sampling of sediments from the ponds and streams, and the installation and development of well 75092, at the base of the Pond A-4 dam (IHSS 142 4)

3 9 2 2 Geology

The geologic characterization of IHSSs 142 1-142 4, within the North Walnut Creek drainage is based upon lithologic information obtained during the sampling of 20 pond sediment sites and the installation of well 75092 during the OU6 Phase I field investigation Other sources of data used to characterize these IHSSs include the lithologic logs from historic wells within the North Walnut Creek drainage, listed in Table 3 5-2, and lithologic logs from piezometers installed during the Earthen Dams projects (EG&G 1993a and 1994d) These lithologic logs and data are contained in Appendixes C2, C3 and C4 The surface geologic map (Plate 3 5-2) was also used to characterize the areal extent of surficial geologic units within IHSSs 142 1 through 142 4 The level of detail in the following discussion of subsurface geology is limited to the shallow pond sediment cores and the geologic information provided by the borings and wells mentioned above Geologic cross section A-A' (Figure 3 5-7) transects the North Walnut Creek drainage to illustrate the stratigraphic relationship of the unconsolidated surface deposits and the inferred bedrock surface in the valley Geologic cross section B-B' (Figure 3 5-8) illustrates the stratigraphic relationship of the unconsolidated surface deposits and the inferred bedrock surface longitudinally along North Walnut Creek

Plate 3 5-2 shows that pond sediment, classified as Valley-Fill Alluvium, covers 95 percent of IHSSs 142 1 142 2 and 142 4 and approximately 75 percent of IHSS 142 3 Colluvium along the hillsides and artificial fill from the dams cover the remaining portions of the A-Series Ponds North Walnut Creek contains up to 12 5 feet of Valley-Fill Alluvium with the thickest interval occurring in the broad flood plain near the confluence of North Walnut Creek with South Walnut Creek Valley-Fill Alluvium within North Walnut Creek (outside the pond IHSSs) consists of reworked RFA High Terrace Alluvium colluvium and reworked bedrock The gravel fraction of Valley-Fill Alluvium is predominantly angular to sub-angular poorly to well graded and consists of quartzite, while the sand is typically fine to coarse sub-angular to subrounded quartz and quartzite grains

Subsurface samples from wells 1286 (located within Pond A-3) 40991 and 1186 41091 and 75092 (located near the base of the Pond A-4 dam, within IHSS 142 4) indicate that the Valley-Fill Alluvium at these locations consists of silty clays, organic clays clayey sands and sandy and clayey gravels (Appendixes C2 2 and C3 3) Pond sediment collected in each of the A-Series Ponds contained Valley-Fill Alluvium consisting of silty clays, organic clays and some clayey sands varying in color from olive-gray to black (Appendix C4) Sediment cores collected from the A-Series Ponds indicate sediment thicknesses ranging from 2 8 inches to 22 7 inches (Table 3 5-4)

Based upon previously discussed projections of bedrock attitudes (Section 3 5 2) and the surface geology bedrock underlying the Valley-Fill Alluvium in the vicinity of the A-Series ponds is part of the Laramie Formation Bedrock includes interbedded sandstones, siltstones, and claystones observed in cores and outcrop Five monitoring wells and two pond sediment sample sites located within IHSSs 142 1-142 4 encountered Laramie strata Three of the wells

(1186, 75092 and 41091) are located relatively close together (less than 350 feet apart), approximately 200 to 250 feet downstream of the A-4 dam In well 1186, one foot of dark yellowish brown to yellowish gray claystone overlies silty sandstone at an elevation of 5,702 feet MSL (Figure 3 5-8) The sandstone is very fine-grained with abundant silt, light gray in color, with iron-oxide staining present locally and in fractures The sandstone is weathered and is slightly to moderately friable In Well 75092, a grayish brown to reddish brown sandy siltstone was encountered at 5 717 feet MSL beneath Valley-Fill Alluvium The siltstone is sandy (44 5 percent sand by volume) with fine-grained, sub-angular to sub-rounded grains and an estimated porosity of less than 20 percent. This unit is underlain by a silty claystone. Well 41091 encountered a yellowish-gray claystone, with trace amounts of silt and sand beneath Valley-Fill Alluvium Sediment core samples from sites SED61692 and SED61792 in Pond A-4 (IHSS 142 4) also encountered Laramie sandstone and silty claystone (Table 3 5-4)

Laramie claystones, silty claystones, and clayey siltstones (gray to grayish orange in color) underlie the Valley-Fill Alluvium in wells 1286 and 40991 near Pond A-3 (IHSS 142 3, Figure 3 5-8)

Laramie sandstones crop out on the northern bank of Pond A-2 (IHSS 142 2) The sandstones at this outcrop location are yellow-brown and yellow-orange in color, indurated, with sub-rounded to rounded fine-grained sand The sandstone is convoluted and folded with distinct bedding and concretions Red-brown ironstone caps the sandstone outcrop, which is approximately 4 to 5 feet thick The water level of Pond A-2 was approximately 5 feet below the base of the sandstone outcrop during the period the surface geology of OU6 was being mapped (January 1994) No outcropping sandstone was observed downstream of IHSS 142 4 (Pond A-4) within the OU6 study area

The A-Series Pond dams (A-1 through A-4) were constructed within North Walnut Creek to control surface water and shallow groundwater The original construction plans for the pond dams (by K R White Company and U S Army Corps of Engineers [USACE]) and the borehole and well logs from the initial dam construction investigation provide the basis for the following brief discussion of the site geology, subsurface soils and construction of the A-Series dams Additional dam investigations (EG&G 1993a and 1994d) and associated borehole and well logs were also reviewed for this report Borehole and well logs from the dam investigations are contained in Appendix C-3 7

In 1952 the A-1 and A-2 dams were constructed north of IHSS 156 2 (Figure 3 5-2) Material used for dam construction consisted of clays, clayey gravels (colluvial) and claystone bedrock, and was obtained from the adjacent hillsides (EG&G 1971)

In 1974 the A-3 dam was constructed north of IHSS 216 1 (Figure 3 5-2), using onsite weathered claystone, and sands and gravels An outer embankment shell was constructed of semipervious sandy gravelly materials with a pervious blanket drain beneath the downstream portion An impervious clay core and cutoff trench were constructed using weathered claystone The dam foundation is sandy silt silty and clayey sandstones, and gravel alluvium resting on weathered sandstones and claystones that overlie unweathered gray claystone (EG&G 1993a)

In 1979 the A-4 dam located northeast of Pond B-5, was constructed by the USACE The embankment fill consists of clayey gravel 0 to 3 feet thick underlain by 14 feet to 45 feet of clay and sandy clay The natural foundation materials beneath the embankment fill consists of alluvium claystone, and weathered claystone (EG&G 1994d)

Dam construction plans show that the A-3 and A-4 dams were keyed into bedrock by excavating a 5-foot cutoff trench into the bedrock along the long axis of the dam foundation (EG&G 1971 and EG&G 1994d) The A-1 and A-2 dams were not keyed into the bedrock, based on the investigation report (EG&G 1971)

3 9 2 3 Hydrogeology

UHSU groundwater at the A-Series Ponds (IHSSs 142 1-4) flows to the east-northeast UHSU groundwater occurs predominantly in Valley-Fill Alluvium along the North Walnut Creek drainage and to a limited extent in the colluvium (Figure 3 6-1) Valley-Fill Alluvium deposits are present in an erosional low bedrock feature (paleochannel) that underlies the present North Walnut Creek drainage (Plate 3 5-3) The Valley-Fill Alluvium which is partially to completely saturated in the A-series pond area receives groundwater discharging from colluvium RFA and Valley-Fill Alluvium deposits in upgradient areas of the drainage

Potentially UHSU groundwater is also present in weathered bedrock underlying the unconsolidated surface materials (Figure 3 5-8)

Vertical gradients for UHSU/LHSU well pairs in the North Walnut Creek drainage were calculated The vertical gradient between well 1586 (Valley-Fill Alluvium) and well 1486 (LHSU sandstone/claystone) was 0 13 feet/foot downward The vertical gradient between well 1786 (Valley-Fill Alluvium) and well B208689 (LHSU claystone) was 1 33 feet/foot downward The approximate average horizontal hydraulic gradient was 0 035 feet/foot in the Valley-Fill Alluvium

Hydrographs for wells 1386, 1586, 1786, B208589, B208789, B210489, and P209989 (IHSS 142 1 area Appendix C6) indicate seasonal effects on the groundwater elevations due to recharge Recharge is highest in spring and early summer months, due to precipitation events Rapid rises in groundwater levels occur during this period, followed by a period of decline in groundwater elevation during the remainder of the year

Recharge from or into the A-Series Ponds likely influences water levels in the Valley-Fill Alluvium Limited well data are available in the pond areas, however, it is assumed that the alluvium is saturated beneath and in the vicinity of the individual ponds

3 9 2 4 Surface Water

Operation of the A-Series Ponds and control of the surface water runoff is discussed in Section 3 7 2 The site descriptions and waste-related histories of IHSSs 142 1-4 are presented in Section 1 3 2 3 The pond IHSSs 142 1-4 are located in the sub-basin drainage identified as WA11 (Figure 3 7-1), which is 5 percent impervious as shown on Table 3 9-1 The soils in this sub-basin have a low infiltration rate (1 3 in/hr)

Volumes of water in the A-Series Ponds vary seasonally, but are usually maintained at 10 percent capacity Individual pond volumes and surface areas at 100 percent capacity are listed in Table 3 9-2 The total discharge for 1992 from Ponds A-3 (February 22 to November 13, 1992) and B-5 to Pond A-4 (January 13 to December 24 1992) was 25 62 millions of gallons (Mgal) and 64 47 Mgal, respectively The total 1992 discharge off site

(January 1 to December 24 1992) from Pond A-4 was 92 7 Mgal which is in approximate agreement with the sum of the inflows from Ponds A-3 and B-5 (EG&G 1993c)

3 9 3 B-Series Ponds (IHSS 142.5-142 9)

3 9 3 1 Site Description

South Walnut Creek is an east-northeast flowing stream that has incised the pediment and cut into predominantly Cretaceous claystone bedrock The drainage extends for a length of 0 98 mile from the buffer zone access road on the west to the Walnut Creek confluence to the east Elevations range from 5,920 feet MSL at the west to 5 710 feet MSL in the east, at a grade of approximately 4 1 percent The hillslopes adjacent to the South Walnut drainage vary from 7 8 degrees to 15 1 degrees from horizontal

The B-Series Ponds constructed by placement of earthfill dams across South Walnut Creek, are Ponds B-1 B-2, B-3 B-4 and B-5 (IHSSs 142 5 through 142 9 Figure 1 3-6) These IHSSs occupy 7 8 acres collectively The largest to smallest ponds are Pond B-5 (3 4 acres) Pond B-4 (1 3 acres) Pond B-2 (1 2 acres), Pond B-1 (1 1 acres), and Pond B-3 (0 8 acres) The waste-related activities and histories of IHSSs 142 5 through 142 9 are discussed in Section 1 3 2 4 The OU6 Phase I field investigation within the South Walnut Creek drainage included sediment sampling in the ponds and streams, and the installation and development of well 75292 at the base of the Pond B-5 dam (east of IHSS 142 9)

3 9 3 2 Geology

The geologic characterization of IHSSs 142 5-142 9 is based upon lithologic information obtained during the sampling of 25 pond sediment sites and the installation of well 75292 during the OU6 Phase I field investigation Other sources of data used to characterize these IHSSs include the lithologic logs from historic wells within the South Walnut Creek drainage listed in Table 3 5-2 and lithologic logs from piezometers installed in dams B-1 and B-3 during the Earthen Dams projects (EG&G 1993a and 1994d) These lithologic logs and data are contained in Appendixes C2 C3 and C4 The surface geologic map (Plate 3 5-2) was also used to characterize the areal extent of surficial geologic units within IHSSs 142 5 through 142 9 The level of detail in the following discussion of subsurface geology is limited to the shallow pond sediment cores and the geologic information provided by the borings and wells mentioned above Geologic cross section A-A' (Figure 3 5-7) transects the South Walnut Creek drainage to illustrate the stratigraphic relationship of the unconsolidated surface deposits and the inferred bedrock surface in the valley Geologic cross section C-C' (Figure 3 5-9) illustrates the stratigraphic relationship of the unconsolidated surface deposits and the inferred bedrock surface along South Walnut Creek

Plate 3 5-2 shows that Valley-Fill Alluvium, consisting primarily of pond sediments, covers 50 to 95 percent of the IHSSs within the South Walnut Creek Colluvium along the hillsides and to a lesser extent, artificial fill from the dams cover the remainder of the IHSS areas The South Walnut Creek drainage is covered with approximately 5 5 to 10 5 feet of Valley-Fill Alluvium which occupies the stream channel and pond beds Width of the Valley-Fill Alluvium within the South Walnut Creek drainage varies from approximately 20 to 250 feet Valley-Fill Alluvium within South Walnut Creek (outside the pond IHSSs) consists of silty clays, clayey sands, and sandy and clayey gravels The Valley-Fill Alluvium contains lower terrace gravels and overlies claystone of the Arapahoe and Laramie Formations

Lithologic logs from wells 3686 (located upstream of IHSS 142 5) 3786 (located upstream of IHSS 142 9) and 3886 (located downstream of IHSS 142 5) indicate the Valley-Fill Alluvium consists of yellow-brown to gray silty clays, sandy clays, and clayey sands with abundant gravel (Appendix C3 3) The gravel is moderately to well-graded, sub-angular to sub-rounded with fine to coarse-grained sand that is angular to sub-rounded Sandy clays with cobbles and gravel are present near the contact of the alluvium and silty claystone bedrock in well 3886

Pond sediment cores collected during the OU6 Phase I investigation in each of the B-Series Ponds contained Valley-Fill Alluvium consisting of silty clays, highly organic clays, silty sands, and some sandy silts, varying in color from olive-gray to black The B-Series Pond sediment cores indicate sediment thicknesses range from 2 5 inches to 31 5 inches (Table 3 5-4) No pond sediment borings were advanced deep enough to encounter bedrock in the South Walnut Creek IHSSs Table 3 5-4 lists the pond sediment core soil classifications

Cretaceous sandstones outcrop on the north and south hillsides upslope from IHSSs 142 7 (B-3 dam) and 142 8 (Pond B-4) These sandstones have been weathered and are unconsolidated at the surface The sandstones are fine grained, sub-angular to sub-rounded with some silt and clay The sandstone varies slightly in color from olive-gray to brown The sandstone outcrop on the hillside north of the B-3 dam is at least 20-feet thick and occurs between 5 880 feet and 5,860 feet MSL The base of the sandstone appears to be immediately above the contact between the dam and hillside The basal contact is gradational transitioning onto a sandy clay No stike or dip measurement could be taken at this contact The elevation and textural characteristics of this sandstone suggest it may be the Arapahoe No 1 Sandstone possibly the lower extent of the sandstone outcropping on the hillside north of IHSS 216 1 This occurrence suggests the No 1 Sandstone may be as much as 50 feet thick under IHSS 216 1 The outcropping sandstone found along the southern hillside near the inlet to Pond B-5 (IHSS 142 9) is identified as the No 1 Sandstone in the Draft OU2 Phase II RFI/RI Report (DOE 1993d) This stratum is up to 45 feet thick and occurs between 5 880 to 5 835 feet MSL Elevations of the top of the sandstone at the outcrops north and east of IHSS 216 1 (5910 feet and approximately 5,870 feet MSL respectively) indicate an easterly dip of approximately 2 9 degrees from horizontal Plate 3 5-2 shows the locations of these outcropping sands along the hillsides adjacent to South Walnut Creek

The B-Series Pond dams (B-1 through B-5) were constructed within South Walnut Creek to control surface water and shallow groundwater The original construction plans for the pond dams (by K R White Company and USACE) and the borehole and well logs from the initial dam construction investigation provide the basis for the following discussion of the site geology subsurface soils and construction of the B-Series dams Additional dam investigations (EG&G 1993a and 1994d) and associated borehole and well logs were also reviewed for this report The borehole and well logs from the dam investigations are contained in Appendix C3 7

Dam construction began in the mid-1950s with several periods of repair and maintenance on the dams during the 1970s and 1980s The Ken R White Company completed construction of earthen dams B-2 B-3 and B-4 by 1955, and the B-1 dam by 1964 The terminal B-5 dam was completed in 1979 by the USACE All of the B-Series Pond dams were constructed out of native materials from the adjacent hillsides and borrow pits located near each dam These construction materials consisted of weathered claystone and gravelly to cobbly clays

The B-1 dam was constructed along South Walnut Creek, east of IHSS 141 (Figure 3 5-2), using material from the adjacent hillside In 1972, additional construction on the B-1 and B-2 dams involved raising the top of the dams five feet and extending the embankment downstream Onsite weathered claystone was used in this construction. The natural foundation material underlying the embankment consists of well-graded gravels and weathered and unweathered claystone of the Arapahoe and Laramie formations

The natural foundation material underlying the B-3 dam consists of organic silts and weathered and unweathered claystones of the Arapahoe and Laramie formations (Dow 1972a, Dow 1972b, EG&G 1971, EG&G 1993a) These materials consisted of weathered claystone and gravelly to cobbly clays A new embankment was also constructed on the B-3 dam in 1972 The embankment was comprised of clays and clayey gravel

The B-5 dam was constructed using material from adjacent hillsides Additional improvements were made throughout the 1980s to prevent cracks and movement During the 1994 dam investigation test holes found embankment fill at thicknesses of 23 feet to 56 feet overlying claystone bedrock In some test holes, 2 feet to 5 feet of clayey, sandy gravel (alluvium) was found overlying bedrock The embankment fill consists of approximately 0 to 1 feet of clayey gravel underlain by 22 to 56 feet of clay and sandy clay Foundation materials encountered beneath the embankment fill consisted of alluvium, claystone and very sandy claystone (EG&G 1994d, Rockwell 1979c DOE 1984)

Dam construction plans show that the terminal B-5 dam was keyed into the bedrock by excavating a 5-foot cutoff trench into the bedrock along the long axis of the dam foundation (Rockwell 1979c) Dams B-1 through B-4 were not keyed into the bedrock, based on the investigation report (EG&G 1971)

The South Walnut Creek drainage was filled with large amounts of artificial fill at two locations (Plate 3 5-2) Infilling brought these areas up to grade for the PA security fence and for road construction across South Walnut Creek and within IHSS 141

3 9 3 3 Hydrogeology

UHSU groundwater in the B-Series Ponds (IHSSs 142 5-142 9) occurs predominantly in Valley-Fill Alluvium along the South Walnut Creek drainage and potentially in underlying weathered bedrock (Figure 3 5-9) Based on Figure 3 6-1, groundwater flow is down valley to the east northeast The approximate average horizontal hydraulic gradient is 0 035 feet/foot in the Valley-Fill Alluvium (Figure 3 6-1) Colluvium and, to a limited extent, artificial fill make up the remainder of saturated surface materials in the vicinity of the B-Series Ponds The underlying weathered bedrock is composed mainly of claystone with some sandstone and siltstone Sandstones and siltstones subcrop beneath the embankment materials as observed in Pond B-3 dam piezometers TH046892 and TH046992, respectively (Appendix C3 7) The sandstone encountered in TH046892 (Figure 3 5-9) is fine grained and was dry to moist when drilled and is not expected to transmit significant quantities of groundwater The presence of sandstone and siltstone units beneath the Pond B-3 embankment (Figure 3 5-9) suggests that groundwater may flow beneath this dam In general, the B-series Ponds act as barriers to flow within the Valley-Fill Alluvium

Recharge from and into the B-Series Ponds likely influences water levels in the Valley-Fill Alluvium Hydrographs (Appendix C6) indicate seasonal fluctuations due to recharge events The hydrograph for well 3686, located upgradient of Pond B-1 indicates rapid increases in groundwater levels in response to spring and early summer precipitation events Water levels then decrease gradually throughout the rest of the year The same effect is observed in well 2886 The maximum thickness of saturated surface materials observed in well 3886 was 11 feet (Figure 3 6-2) Wells 3786 and 3886 are occasionally dry and well 3686 is often dry

3 9 3 4 Surface Water

Operation of the B-Series Ponds and control of surface water runoff in the South Walnut Creek drainage is discussed in Section 3 7 2 The site descriptions and waste-related histories of IHSSs 142 5-9 are presented in Section 1 3 2 4 Ponds B-1 through B-4 (IHSSs 142 5-8) are located in drainage SWA3, and Pond B-5 (IHSS 142 9) is located in drainage sub-basin SWA1 (Figure 3 7-1) The existing impervious areas in SWA3 and SWA1 are 3 and 7 percent respectively and the soils in both basins have a low to moderate infiltration capacity (Table 3 9-1)

The individual pond volumes and surface areas at 100 percent capacity are listed in Table 3 9-2

3 9 4 W & I Pond (IHSS 142 12)

3 9 4 1 Site Description

The W&I Pond (IHSS 142 12) is located along Walnut Creek, approximately 350 feet west of Indiana Street (Figure 1 3-3) IHSS 142 12 occupies 0 7 acres within the flood plain The flood plain is relatively level and exists at approximately 5,650 feet MSL The history and waste-related activity of IHSS 142 12 is discussed in Section 1 3 2 5

3 9 4 2 Geology

The geological characterization of the UHSU within the W & I Pond (IHSS 142 12) is based upon lithologic information obtained from the sampling of five pond sediment sites during the OU6 Phase I field investigation (Figure 3 5-4), the lithologic logs from monitoring wells 0486 and 41691, and the surface geologic map (Plate 3 5-2) Lithologic logs and data are contained in Appendixes C3 3 and C4 The surface geologic map (Plate 3 5-2) was also used to characterize the areal extent of surficial geologic units within IHSS 142 12 The level of detail in the following discussion of subsurface geology is limited to the shallow pond sediment cores and the geologic information provided by the borings and wells mentioned above

Valley-Fill Alluvium, consisting primarily as pond sediments, covers approximately 95 percent of IHSS 142 12 Artificial fill covers approximately 5 percent of IHSS 142 12 at the western edge The width of Valley-Fill Alluvium within the Walnut Creek drainage at IHSS 142 12 is approximately 500 feet across The pond sediments collected from IHSS 142 12 indicate the Valley-Fill Alluvium at this site consists of clays and organic clays varying in color from olive-gray and gray-brown to black (Table 3 5-4) No bedrock was observed in the pond sediment cores

The Valley-Fill Alluvium encountered in wells 0486 and 41691, located southeast of IHSS 142 12 consists of clays sandy clays, clayey gravels, and gravelly sands ranging in thickness from 10 to 14 feet Gravels and gravelly sands are poorly-graded sub-angular to sub-rounded and consist predominantly of quartzite The dominant colors vary from yellow-brown to yellowish-orange The clayey gravels near the base of the Valley-Fill Alluvium may represent lower terraces within the valley Bedrock encountered in historical wells consists of claystones and sandy claystones with very fine-grained to fine-grained sand some interbedded silt and iron-oxide as staining and nodules

3 9 4 3 <u>Hydrogeology</u>

Hydrogeologic data specific to the W&I Pond area (IHSS 142 12) are limited to data from well 41691 located approximately 500 feet east of the W&I Pond Water levels in this well vary only 1 to 2 feet during the year and indicate a saturated thickness of approximately 8 to 10 feet Seasonal recharge effects on water levels at this well are not evident (hydrograph in Appendix C6) It is expected that UHSU groundwater flow in the area occurs predominantly within Valley-Fill Alluvium towards the east The degree of saturation within Valley-Fill Alluvium in the area upgradient of the W&I Pond is likely influenced by the release of water from Pond A-4 and water originating west of RFETS from the McKay Ditch and Bypass Canal Downstream of the W&I Pond the degree of saturation is likely influenced by the W&I Pond and by releases of water to the Broomfield Diversion Ditch

3 9 4 4 <u>Surface Water</u>

The W&I Pond is located in Walnut Creek downstream of the confluences of North and South Walnut Creeks The site description of IHSS 142 12 is presented in Section 1 3 2 5 When the capacity of the pond is exceeded the overflow is discharged to the Broomfield Diversion Ditch A small amount of directed water escapes from the flume into Walnut Creek east of Indiana Street

The W&I Pond (IHSS 142 12) is located in sub-basin WA1 (Figure 3 7-1) The existing impervious area in WAI is approximately one percent with soils characterized by low infiltration rates (Table 3 9-1)

3 9.5 Old Outfall Area (IHSS 143)

3 9.5 1 Site Description

The Old Outfall Area (IHSS 143) is located to the northwest of Buildings 773 and 771 within the PA (Figure 1 3-7) The ground elevation of IHSS 143 is approximately 5,942 feet MSL and the area surrounding the IHSS is relatively level The investigated Old Outfall Area, where the laundry effluent pipe from Building 771 drains, occupies about 0 04 acres Disturbed ground and artificial fill cover the entire IHSS 143 area and to at least 100 feet beyond the IHSS boundaries

This IHSS is situated on top of a former stream channel that drained into North Walnut Creek Based on historic aerial photographs (1964 and 1975), the Old Outfall drainage flowed to the north and converged with North Walnut Creek Artificial fill material was used to fill in the channel for installation of a segment of the PA fence and a parking lot that is currently occupied by trailers The waste-related activities and history of IHSS 143 are discussed in Section 1 3 2 6

3 9 5 2 Geology

The geologic characterization of IHSS 143 is based primarily on information obtained from five borings (60092 through 60492) and one well (77492) drilled during the OU6 Phase I field investigation (Figure 3 5-1) This characterization is limited to a narrow area of the former drainage (Section 3 9 5 1) where the OU6 Phase I borings were drilled The geologic interpretation is supplemented with information from the surface geologic map (Plate 3 5-2) and the lithologic log from historical well 1986 (Table 3 5-2)

Artificial fill material covers the entire surface area of IHSS 143 (Plate 3 5-2) The artificial fill encountered during the OU6 Phase I field investigation consists of sandy clays, clayey sands and gravels and sandy gravels Gravels consist of angular to sub-angular quartzite (up to 0 2 feet in diameter observed in core samples) Sands are fine- to coarse-grained angular to sub-rounded quartz and quartzite Color varies from olive and yellow-brown, reddish yellow and brown, to white (caliche) and black Caliche coats gravel and sand grains and occupies voids in the clays The artificial fill is weathered throughout and iron-oxide staining is present A black, fine to coarse-grained unconsolidated sand (0 2 feet thick) observed in borings 60192 and 60292 delineates the contact between artificial fill and RFA Artificial fill at IHSS 143 is approximately 6 5 feet thick Results of a grain size analysis performed on a grab sample collected from 0 to 2 feet at boring 60292 are presented in Table 3 5-3

Below the artificial fill, the RFA consists of sandy and clayey gravels and clayey sands, varying in color from brown to yellow and gray The gravel is angular and consists of quartzite Sand in the RFA is fine to coarse-grained angular to sub-angular, and consists of quartz and quartzite grains The thickness of the RFA encountered in well 77492 is approximately 17 feet

Silty claystone in boring 60692 (located upgradient of IHSS 143) and in well 77492 is brownish-yellow to grayish-brown in color The sand fraction is fine-grained sub-angular quartz, with a trace of sub-angular quartzite gravel Extensive iron-oxide staining is present in the claystone with calcium carbonate coating fractures at angles of 30-degrees from horizontal The claystone encountered during drilling was moist to very moist

3 9 5 3 Hydrogeology

Groundwater level measurement in IHSS 143 (well 77492) indicates that flow within the unconsolidated surface deposits (RFA) occurs to the north, following an erosional low in the top of bedrock (Plate 3 5-3) and discharges to the Valley-Fill Alluvium north of the IHSS (Figure 3 6-1) The maximum saturated thickness of surface material observed near IHSS 143 is approximately 12 feet (Figure 3 6-2) The hydrograph for well 1986 (Appendix C6) indicates little variance in groundwater elevation (1 to 2 feet) from seasonal recharge events The Stiff diagram for well 1986 (Figure 3 6-9) shows a water type higher in Na^+ plus K^+ than Ca^{+2} a condition that is atypical of the UHSU at RFETS (Section 3 6 2 2) This water type is likely due to an increased ion-exchange in groundwater due to greater residence time that occurs when recharge from precipitation is not a strong influence

3 9.5 4 Surface Water

IHSS 143 is located in sub-basin CWAC (Figure 3 7-1), where soils have a relatively high infiltration rate (Table 3 9-1) The Old Outfall Area is approximately 50 percent impervious

3 9 6 Soil Dump Area (IHSS 156.2)

3 9 6 1 Site Description

The Soil Dump Area (IHSS 156 2) is located on the interfluve between North Walnut and South Walnut Creeks, occupying the mesa east of the buffer access road (Figure 1 3-3) This IHSS covers approximately 9 8 acres Ground surface elevations at this IHSS vary slightly from 5 954 to 5,946 feet MSL The ground surface slopes slightly to the east at approximately 1 5 degrees from horizontal The hillside north of IHSS 156 2 slopes more gently into North Walnut Creek (6 7 degrees) than the hillside south of IHSS 156 2, which slopes 13 4 degrees into South Walnut Creek

The area within IHSS 156 2 consists of discarded soils asphalt, concrete and some construction debris as shown on historic aerial photographs (1971 and 1977) The debris was dumped on the top and sides of the mesa, and the thickness of fill material appears to be greater along the edges The disturbed surface does not extend laterally beyond the areal extent of the RFA within IHSS 156 2 The history and waste-related activities of IHSS 156 2 are discussed in Section 1 3 2 7

3 9 6 2 Geology

The geologic characterization of the UHSU within IHSS 156 2 is based on information obtained from 22 borings (Table 2 1-9) and one well (75892) drilled during the OU6 Phase I field investigation (Figure 3 5-1) and the surface geologic map (Plate 3 5-2) Lithologic logs for the borings are found in Appendix C2 5 Geologic cross sections E-E' (Figure 3 9-3) and F-F' (Figure 3 9-4) illustrate the stratigraphic relationship of the unconsolidated surface materials and the underlying bedrock surface

The ground surface of IHSS 156 2 consists of artificial fill and RFA A change in surface slope indicates the contact between the more resistant artificial fill/RFA and the underlying bedrock The combined artificial fill and RFA interval varies in thickness from 4 9 to 23 1 feet and thickens predominately in the northern direction as shown on Figure 3 9-4 The artificial fill/RFA interval consists of sandy gravels, silty sands, gravelly sands, clayey sands and reworked bedrock Results of grain size analyses performed on grab soil samples collected between 0 and 2 feet from borings 73992 and 74192 are presented on Table 3 5-3 The gravel in cored samples is poorly to well graded angular to sub-angular and ranges from 0 1 to 0 2 feet in diameter The sand is fine- to coarse- grained angular to sub-rounded, and poorly to well sorted Color varies from shades of brown gray and white to yellow and red

Artificial fill material consists of reworked RFA and is nearly indistinguishable from native RFA in core samples The artificial fill/RFA contact shown in Figures 3 9-3 and 3 9-4 is defined by the presence of a caliche zone observed in several of the core samples from borings 73992 74392 74492 and 74592 The presence of caliche especially as a well defined zone is believed to represent undisturbed native soil However if native soils were mixed with the fill material placed in IHSS 156 2, the caliche zone observed in core may not accurately reflect the artificial fill/RFA contact

The underlying bedrock within IHSS 156 2 consists of claystone, clayey sandstone, sandy claystone and silty sandstone as depicted by cross sections E-E' (Figure 3 9-3) and F-F' (Figure 3 9-4) The color of the sandstone varies with the degree of weathering and ranges from light gray and white (unweathered) to yellow and brown (extensively weathered) A shallow erosional surface appears to be present at the top of bedrock in IHSS 156 2, as shown by a slightly thicker RFA interval in boring 74892 (Figure 3 9-3) The artificial fill and RFA interval thickens on the north side of IHSS 156 2 (Figure 3 9-4) in response to the erosional nature of the top of bedrock surface (Plate 3 5-3) in this area

Sandstones crop out along the roadcut through the western end of IHSS 156 2 (Plate 3 5-2) at approximately the same elevation as the top of sandstones encountered in the IHSS 156 2 borings 73792 (5 948 feet MSL) and 77792 (5 933 feet MSL) In the OU2 Mound Area the top of the Arapahoe No 1 Sandstone was encountered at 5 940 feet MSL in well B217689 (DOE 1993d) The lithology of the outcropping sandstones is similar to sandstones encountered in the OU2 and OU6 borings clayey sandstones with fine to medium-grained angular to subround quartz grains, and iron-oxide stain on the grain surfaces The similarities in the top of sandstone elevations and lithologies in IHSS 156 2 and the OU2 well indicate the sandstones observed in IHSS 156 2 are probably the No 1 Sandstone The top of bedrock map (Plate 3 5-3) identifies those borings that encountered the No 1 Sandstone and outcrops of No 1 Sandstone within the vicinity of IHSS 156 2

3 9 6 3 Hydrogeology

Hydrogeologic data from well 75892 (Table 3 6-1 and Appendix C6), the only active well located in the area, indicated that unconsolidated surface materials in IHSS 156 2 are unsaturated (Figure 3 6-1) Shallow UHSU groundwater may exist seasonally in colluvial materials and flow down the north and south flanks of the mesa on which the IHSS is located

Groundwater is potentially present in weathered bedrock underlying the surface materials As stated in Section 3 9 6 2, clayey and silty sandstones have been encountered within IHSS 156 2 However, the sandstones encountered in borings 77792 and 73792 were dry when drilled

3 9 6 4 Surface Water

Based on the topography within IHSS 156 2, surface water runoff drains toward both North Walnut and South Walnut Creeks and toward the east off the mesa. The majority of IHSS 156 2 is located on the divide of drainage sub-basins WA11 and SWA3 (Figure 3 7-1), which have soils of low to moderate infiltration rates (Table 3 9-1) The western portion of the IHSS also straddles drainage sub-basins CWAB and CSWAB (Figure 3 7-1), which have high infiltration rates (Table 3 9-1) This IHSS is approximately 5 percent impervious

3 9 7 Triangle Area (IHSS 165)

3 9 7 1 Site Description

The Triangle Area (IHSS 165) is located in the northeastern portion of the RFETS security area (Figure 1 3-3) The Triangle Area covers approximately 39 1 acres on a broad, relatively flat mesa at an elevation of approximately 5 960 feet MSL The ground surface slopes to the east at approximately 0 7 degrees from horizontal The waste-related activities and history of IHSS 165 are discussed in Section 1 3 2 8

3 9 7 2 Geology

The geologic characterization of the UHSU within IHSS 165 is based on information obtained from 12 borings (72292 through 73092 and 73292 through 73492) and two wells (76192 and 76292) drilled during the OU6 Phase I field investigation (Figure 3 5-2) Lithologic logs from historical wells within the PA OU2 OU4 and OU6 (Appendix C3) were also used in characterizing the geologic conditions in IHSS 165 New and existing data were used to contour the top of bedrock surface in this area (Plate 3 5-3) Geologic cross section G-G' (Figure 3 9-5) illustrates the stratigraphic relationship of the unconsolidated surface materials to the underlying bedrock surface

Artificial fill material covers the entire surface area of IHSS 165 (Plate 3 5-2) The top of the mesa in the area of IHSS 156 2 consists of disturbed artificial fill and RFA near the surface The contact between the artificial fill and RFA is not discernible in the drill core samples The artificial fill/RFA interval consists of gravelly sands with minor amounts of clayey silts, silts, and silty clays Results of a grain size analysis performed on a grab soil samples collected between 0 and 2 feet from boring 72292 is presented on Table 3 5-3 Soils within six feet of the surface are predominantly clay, gravelly sands, and clayey, sandy gravels which vary in thickness from approximately 4 feet across the top of the mesa to 10 feet on the north side of IHSS 165 Color varies from brown red yellow and white to gray and olive The gravel is angular to subangular quartzite The sand fraction is variable, ranging from fine- to coarse-grained poorly to well-sorted, with angular to rounded quartz and quartzite The artificial fill/RFA contains some reworked bedrock and possible landslide material that is extensively weathered with iron-oxide staining and caliche Fractures in the bedrock vary from 0 to 10 degrees from horizontal, with caliche observed along the fracture surfaces

Cretaceous bedrock observed in cores collected during the OU6 Phase I investigation and in historical wells is comprised of sandy and silty claystone claystone, clayey siltstone sandstone and silty sandstone The bedrock varies in color from gray yellow, brown and white (weathered) to olive (unweathered) The predominant bedrock type within IHSS 165 is claystone This stratum contains 2 to 26 percent sand, with fine- to coarse-grained, angular to sub-rounded quartz grains The claystone is unweathered to extensively weathered, and shows different degrees of iron-oxide and manganese-oxide staining Calcium carbonate is present in voids and as nodules

The sandstone bedrock observed in borings 72292, 72892, 73392, 73492, and in well 76292 (Figure 3 5-2) is typically fine-grained, with some medium-grained quartz sand The sand content by volume varies from 61 to 82 percent The sandstone is extensively weathered, moderately to highly friable, up to 20 percent porosity, and vertical fractures are present

Sandstones encountered in the IHSS 165 borings 72292, 72892, 73392, and wells 73492 and 76292 appear to be the No 1 Sandstone, based on similarities in textural characteristics and the elevation at which the top of the sandstone was encountered in the borings (approximately 5,940 to 5,950 feet MSL) relative to the No 1 Sandstone present in OU2 borings and wells Thickness of the sandstone observed in IHSS 165 borings range from 1 8 feet to 12 1 feet No borings penetrated the entire thickness of the sandstone unit, therefore, its total thickness is unknown These sandstone units may represent an extension of the Arapahoe No 1 Sandstone channel observed in OU2 (DOE 1993d) The presence of No 1 Sandstone in well 76192 which is located between well 73392 and the outcrops along the road west of IHSS 156 2 (Plate 3 5-3), indicate a limited areal extent of the No 1 Sandstone in OU6 due to erosional downcutting by present-day drainages

The top of the bedrock features within and surrounding IHSS 165 are shown on Plate 3 5-3 and Figure 3 9-5 Two apparent bedrock scours are present The most prominent of these originates from the west center of IHSS 165 and trends southeast toward the bedrock channel underlying the South Walnut Creek drainage This relatively narrow scour is overlain by artificial fill and RFA, up to a maximum thickness of 22 5 feet (well P219489, Figure 3 9-5)

The other bedrock scour is less distinct, and extends from the western portion of the OU4 Solar Evaporation Ponds toward the east-northeast to the bedrock channel underlying the North Walnut Creek This scour extends across the northwestern corner of IHSS 165 Artificial fill RFA and colluvial material (clays, clayey gravels and clayey sands) overlie this bedrock scour

3 9 7.3 Hydrogeology

A northeast-trending scour that appears to onginate west of IHSS 165 (Section 3 9 7 2) extends through the northwestern portion of the IHSS near well P218389 (Plate 3 5-3 and Figure 3 6-2) Approximately 2 feet of saturated RFA was observed at well P218389 in April 1993 (Figure 3 6-2) It is believed that UHSU groundwater flows to the northeast down the hillside in this erosional scour and discharges to Valley-Fill Alluvium in North Walnut Creek near well B208289

The second observed scour discussed in Section 3 9 7 2, crosses the IHSS area at its southwest corner and locally trends to the southeast UHSH groundwater in this scour flows through artificial fill and RFA then discharges to Valley-Fill Alluvium in South Walnut Creek near well 3586 (Figure 3 6-1) The maximum saturated thickness of surface materials observed within this scour was approximately 10 feet in well P219489 (Figure 3 6-2)

Much of the unconsolidated geologic material within IHSS 165 is unsaturated However, groundwater may occur to a limited extent in weathered bedrock flowing both to the south and north

Hydrographs for wells P207689 and P207889 (Appendix C6) indicate seasonal recharge influence on groundwater elevations in the IHSS 165 area Spring and early summer precipitation events cause rapid increases in water levels Throughout the remainder of the year the water levels decrease at a slower rate

For the UHSU well pair P207889 (RFA) and P207989 (weathered claystone) a downward vertical hydraulic gradient of 1 59 feet/foot was observed in April 1993

The water type indicated by the Stiff diagram for well 76292 (Figure 3 6-9) is calcium-bicarbonate typical of the UHSU in OU6 Well 76292 is screened in weathered sandstone (Appendix C2 6) that subcrops beneath unconsolidated surface material (Figure 3 9-5) The water type suggests that the bedrock material is hydraulically connected to saturated surface materials and thus, is part of the UHSU

3 9 7 4 Surface Water

The Triangle Area (IHSS 165) is located west (upgradient) of IHSS 156 2 on the same mesa. This IHSS is located predominantly in drainage sub-basin CWAB (Figure 3 7-1) which has a relatively high infiltration rate (Table 3 9-1) The Triangle Area is approximately 5 percent impervious

3 9 8 Trenches A, B, and C (IHSS 166 1, 166 2, and 166.3)

3 9.8 1 Site Description

Trenches A, B, and C (IHSSs 166 1, 166,2, and 166 3) are located north of the RFETS security area on the mesa between North Walnut Creek and the unnamed tributary This mesa is relatively level in the vicinity of IHSS 166 1-3, with ground surface elevations ranging from 5,971 feet MSL in the west to 5,962 feet MSL in the east (Figure 1 3-9) Collectively, IHSSs 166 1-3 occupy approximately 1 1 acres

IHSS 166 1 (Trench A) is located southeast of the current landfill (IHSS 114) IHSS 166 2 (Trench B) is the southern-most trench IHSS 166 3 (Trench C) consists of two trenches one located east of IHSS 166 1, the other located between IHSS 166 1 and 166 2 The ground surface slopes approximately one degree to the east across the IHSS 166 area. The hillside south of IHSS 166 2 slopes to the south at 9 7 degrees from horizontal The waste-related activities and histories of IHSS 166 1-3 are discussed in Section 1 3 2 9

3 9.8.2 Geology

The geologic characterization of IHSSs 166 1-3 is based on information obtained from borings 66892 through 69392, and two wells, 76992 and 77392, drilled during the OU6 Phase I field investigation (Figure 3 5-1) Additionally historical wells in the vicinity of IHSSs 166 1-3 (Plate 3 5-1) and the surface geologic map (Plate 3 5-2) were also used to characterize these IHSSs Lithologic logs for these borings and wells are found in Appendixes C2 and C3 The stratigraphic relationship of the unconsolidated surface materials to the underlying bedrock surface is shown on cross sections H-H' and I-I' (Figures 3 9-6 and 3 9-7, respectively)

The RFA covers the top of the mesa and underlies IHSSs 166 1-3 (Plate 3 5-2) Within Trenches A, B and C artificial fill material consists of reworked RFA, possibly soil that was originally removed from the trenches at the time of excavation Through time backfill in these areas has settled and shifted, resulting in surface depressions along some portions of the trenches This artificial fill material consists of clayey and sandy gravels gravelly sands and clays silty sands and clays Results of grain size analyses performed on grab soil samples collected at 0 to 2 feet from borings 66892 (IHSS 166 1) and 68692 (IHSS 166 3) are presented in Table 3 5-3 The artificial fill/RFA material varies in color from yellow-brown yellow-orange gray-brown and reddish yellow to gray The gravel consists of angular to sub-angular to sub-rounded quartzite with clasts up to 0 2 feet in diameter observed in core samples Sands consist of fine- to coarse-grained poorly to well-graded, angular to sub-rounded quartz and quartzite grains Portions of the artificial fill material contain reworked bedrock with caliche zones and calcium carbonate filling and coating voids The artificial fill material appears mottled with varying degrees of iron-oxide and manganese-oxide staining Within the trenches the artificial fill/RFA material varies in thickness from 5 feet to 10 6 feet No evidence of sludge or waste material was observed in the drill cores

Cretaceous bedrock underlies the artificial fill/RFA material Bedrock consists predominantly of claystones with some sandstones and siltstones and varies in color from shades of gray yellow and brown to white Sandstone interbedded with the claystone consists of fine-grained well sorted sub-rounded, quartz grains The claystones visually appear to have low porosity (less than 5 percent) and exhibit varying degrees of friability ranging from slightly to highly friable Calcium carbonate (i e caliche) occurs in voids and along fracture planes at angles from 0 to 70 degrees from horizontal Carbonaceous material occurs throughout the bedrock A single occurrence of sandstone is observed in boring 67692 on the west end of IHSS 166 2 (Figure 3 5-1) This unit is 2 6-feet thick and consists of fine-grained, well-sorted angular to sub-rounded quartz grains with argillaceous and silica cement The sandstone exhibits high friability with porosity estimated at less than 10 percent and a sand content of 41 5 percent by volume Bedding planes observed in drill core from this boring dip at an angle of 20 degrees from horizontal

The east-west geologic cross section H-H' (Figure 3 9-6) through IHSS 166 1 shows a relatively flat top of bedrock surface sloping 1 0 degree to the east between boring 67492 and well B206689 The south-north geologic cross section I-I' (Figure 3 9-7) through

IHSSs 166 1-3 shows a relatively flat top of bedrock surface within the trenches, with a change in slope of the bedrock surface to approximately 2 9 degrees, toward well B206389 and the Landfill Pond, occurring just north of boring 66892 (IHSS 166 1) The top of bedrock map (Plate 3 5-3) provides a plan view of the bedrock surface shown in the geologic cross sections

3 9.8.3 Hydrogeology

Trenches A, B, and C are located on a west-east trending mesa in which a groundwater divide exists (Figure 3 6-1) East of the trenches, UHSU groundwater flows to the east through the weathered bedrock Interpreted potentiometric surface contours suggest that south of the trenches, UHSU groundwater flows to the south toward North Walnut Creek This inferred flow to the south occurs within RFA on the mesa and then discharges to Valley-Fill Alluvium in the drainage Immediately north of the trenches, the UHSU groundwater flow direction is to the northeast The flow direction and horizontal hydraulic gradient water levels in wells 6487 (located west of the trenches) and B206389 (located north of Trench A) The surface materials are unsaturated in the area immediately to the east of Trenches A and B (Wells 76992, 77392 Figure 3 6-1) where flow potentially occurs in weathered bedrock

Hydrographs for wells B206489 and 7287, located within IHSS 166 1 (Appendix C6), indicate that water levels are strongly influenced by local recharge, and reflect seasonal effects Well 7287 is occasionally dry and exhibits a maximum saturated thickness within RFA of approximately 6 feet (Figure 3 6-2) The water level in well B206489 (RFA/weathered bedrock) occasionally falls below the top of the bedrock The maximum saturated thickness observed at well B206489 is approximately 6 feet (Figure 3 6-2)

The Stiff diagram for well 7287 (Figure 3 6-9) shows the calcium-bicarbonate type water that is typical of the UHSU The TDS concentration is low in samples from this well, which indicates that recharge from precipitation strongly influences groundwater in this area.

3 9 8 4 Surface Water

Based on topography in the area of IHSSs 166 1-3, surface water runoff drains toward the north and the south These IHSSs are located in drainage sub-basins WA6, WA7, and WA13

(Figure 3 7-1) Soils in these sub-basins have a low to moderate infiltration rate (Table 3 9-1) The Trenches Area is less than 25 percent impervious

3 9 9 North Spray Field and South Spray Field Areas (IHSSs 167 1 and 167.3)

3 9 9 1 <u>Site Description</u>

The North Spray Field and South Spray Field Areas (IHSSs 167 1 and 167 3) are located north of the RFETS security area and north of North Walnut Creek (Figure 1 3-3 page 1 of 2) The Pond Spray Field Area (IHSS 167 2) previously included in the OU6 Phase I investigation (Figure 1 3-3, page 1 of 2) has been moved to OU7 For congruity within the OU6 geologic study area, data collected in the historical IHSS 167 2 area during the OU6 Phase I field investigation are included on Table 3 5-1 (stratigraphic data), Figure 3 5-1 (boring location map), Plate 3 5-3 (top of bedrock map), and Appendix C-2 11 (lithologic logs) The geologic characterization and evaluation of IHSS 167 2, however will be included in the OU7 RFI/RI Report The histories and waste-related activities of IHSSs 167 1 and 167 3 are discussed in Section 1 3 2 10

IHSS 167 1 covers approximately 3 96 acres and is located in the headward portion of the unnamed tributary and adjacent to the northern boundary of the present Landfill (IHSS 114) Two drainages border this IHSS and converge at the eastern apex of IHSS 167 1 (Plate 3 5-2) The ground surface elevations on the mesa range from approximately 5,970 feet MSL on the west to 5,913 feet MSL on the east The eastern half of IHSS 167 1 slopes to the east at approximately 7 degrees from horizontal

The location of IHSS 167 3 was moved (DOE 1992b) after the completion of the OU6 Phase I field investigation The historical IHSS boundary and the revised IHSS boundary are discussed in Section 1 3 2 and shown on Figure 1 3-3 (page 1 of 2) The investigated IHSS 167 3 (historical) covers an area approximately 0 92 acres and is located on the mesa south of the Landfill Pond Bypass and east of Trench C The mesa is relatively flat, with ground surface elevations in the range of 5 959 feet to 5,963 feet MSL The hillside south of IHSS 167 3 slopes to the south approximately 9 7 degrees from horizontal

3 9 9 2 Geology

The geologic characterization of IHSSs 167 1 and 167 3 is based on information obtained from numerous shallow borings and two wells (77192 and 76792, respectively) drilled during the OU6 Phase I field investigation (Figure 3 5-1) The geological interpretation is supplemented with the surface geologic map (Plate 3 5-2) and lithologic logs from historical wells in the vicinity of these IHSSs (Plate 3 5-1, Table 3 5-2) Borings drilled within IHSSs 167 1 and 167 3 during the Phase I field investigation did not exceed a depth of 4 feet, thereby limiting information available from this study to within 4 feet of the surface

IHSS 167 1 RFA at least 4 feet thick covers the top of the mesa in the western half of IHSS 167 1 (Plate 3 5-2) No borings were drilled deep enough to penetrate the base of the RFA in this IHSS The RFA encountered in IHSS 167 1 during the OU6 Phase I field investigation consists of clayey to sandy gravels Color varies from shades of orange, brown, and gray to white Grain size data from selected grab samples (0 to 2 feet) collected from IHSS 167 1 are presented in Table 3 5-3 Well-graded gravel, ranging from large boulders 3 feet in diameter (observed in the field) to 0 1 foot-diameter gravel observed in the core consists of quartzite schist, and quartz A dark reddish-brown or dark red, clayey gravel layer is prominent in this area. Caliche is disseminated throughout the core material Sands consist of fine- to coarse-grained, angular to sub-rounded, quartz and schist grains Field observations indicate the RFA is at least 15-feet thick near the gulch confluence in eastern IHSS 167 1 (Plate 3 5-2)

Colluvium covers the hillside in the eastern portion of IHSS 167 1 A landslide feature is located at the confluence of the drainages just outside of the IHSS boundary The colluvium consists of sandy gravels with fine- to coarse-grained, angular to sub-rounded quartz, quartzite, and schist sand grains The gravel is angular to sub-angular consisting of quartzite and quartz Borings 61992, 62092, and 62792 (Figure 3 5-1) encountered Cretaceous bedrock beneath colluvial cover ranging from 0 feet (boring 62092) to approximately 3 feet thick (boring 62792) The bedrock consists of claystones and silty claystones varying from shades of yellow-brown, gray-white, and yellowish orange to brown The claystone ranges from slightly to moderately weathered, with varying degrees of iron-oxide staining Sand content varies from 2 to 9 percent by volume, and consists of fine-grained, sub-rounded quartz and feldspar grains The claystone is slightly to highly friable Carbonaceous material and caliche are present along fractures and throughout the claystone

IHSS 167 3 The RFA that covers the surface area of IHSS 167 3 is at least 4-feet thick (Table 3 5-1) and consists of clayey and silty gravels and sands, well-graded gravels, and poorly graded sands The color of RFA is yellowish brown white, very dark brown, and gray The gravel and sand grains in this area consists primarily of quartzite and quartz The gravel is coated with caliche acting as a cementing agent Localized iron-oxide staining is also pervasive throughout the core material Bedrock was not encountered in the shallow borings drilled within historical IHSS 167 3 Grain size data from selected grab samples (0 to 2 feet) collected from IHSS 167 3 are presented in Table 3 5-3

Well 76792 located approximately 100 feet north of historical IHSS 167 3 (Figure 3 5-1) encountered RFA and sandy claystones The sand content of RFA is 37 percent by volume and consists of very fine, angular to sub-rounded quartz grains The sandy claystone was highly friable, with an estimated porosity of less than 5 percent The gravel was angular to sub-angular, consisting of quartzite and granite The sand consists of varying amounts of fine to coarse poorly to well-graded angular to sub-rounded quartz and feldspar grains Well 76792 encountered the top of bedrock at 5 937 feet MSL

A bedrock scour extends northeast through well 76792 toward the unnamed tributary Based on field observations at the base of the RFA along the south hillside, the top of bedrock surface on the hillside slopes to the east at approximately 1 5 degrees

3 9 9 3 **Hydrogeology**

Groundwater seepage occurs at the contact between the RFA and colluvium deposits in the two drainages that bound IHSS 167 1 (Plate 3 5-2) Seepage in the drainages suggests that the RFA is saturated to the west and groundwater flow may be channelized in bedrock scours that underlie the surface drainages (Plate 3 5-3) UHSU groundwater in the area is expected to flow to the southeast and discharge to Valley-Fill Alluvium underlying the unnamed tributary of Walnut Creek Bedrock was not encountered in the only well located within IHSS 167 1 (well 77192) thus, little is known about the degree of bedrock saturation in the area

The investigated area for IHSS 167 3 is located to the northeast of well 77392, near IHSS 166 2 (Figure 3 5-1) Well 77392 is screened in RFA, the predominant surface material in the area. The RFA is unsaturated in the area and ground water, if it occurs locally, is likely limited to the weathered bedrock units of the UHSU

An erosional scour in the top of bedrock surface (Plate 3 5-3) is present in the vicinity of the former IHSS 167 3, as described in Section 3 9 9 2 Wells 76992 and 76792 are located near the center of this scour however, these wells are typically dry It appears that the potential for channelized groundwater flow within this scour in the direction toward the unnamed tributary exists, however, flow may occur only during very high recharge conditions Groundwater flow in the scour was not observed during the April 1993 sampling period (Figure 3 6-1)

3 9 9 4 Surface Water

Surface water runoff from IHSSs 167 1 and 167 3 drains toward the unnamed tributary of North Walnut Creek IHSS 167 1 is located in drainage sub-basin WA6 (Figure 3 7-1) which has low infiltrative soils (Table 3 9-1) IHSS 167 3 is located in drainage sub-basin WA7 which has moderately infiltrative soils The North Spray Field Area (IHSS 167 1) contains no impervious surfaces, the South Spray Field Area (IHSS 167 3) is approximately 6 percent impervious The IHSSs 167 1 and 167 3 are currently grass-covered

3 9 10 East Spray Field Area (IHSS 216.1)

3 9 10 1 Site Description

The East Spray Field Area (IHSS 216 1) is located on the narrow interfluve that separates North Walnut Creek from South Walnut Creek, east of IHSS 156 2 (Figure 1 3-3) This IHSS covers 3 4 acres and contains ground surface elevations range from approximately 5,925 feet MSL on the west to 5,911 feet MSL on the east. The surface of the mesa slopes to the east at approximately 1 7 degrees from horizontal The waste-related activities and history of IHSS 216 1 are discussed in Section 1 3 2 11

3 9 10 2 Geology

The geologic characterization of IHSS 216 1 is based on information obtained from six borings drilled during the OU6 Phase I field investigation These borings (78092 through 78592, Figure 3 5-2) were drilled to a total depth of 4 feet The geologic interpretation is supplemented with information from the geologic map (Plate 3 5-2)

The RFA covers the surface of IHSS 216 1 (Plate 3 5-2) and consists of clayey silts gravelly clays silty clays clayey gravels gravelly sands and reworked bedrock The gravel is angular to sub-angular, consisting of quartzite quartz, and schist Sand consists of fine- to coarse-grained poorly to well-sorted angular to rounded quartz quartzite, and schist grains Caliche was disseminated throughout, with slight to extensive iron-oxide staining

Bedrock was encountered in boring 78092 (Figure 3 5-2) The bedrock consists of clayey siltstone with 15 percent sand content by volume The sand is fine-grained angular to rounded quartz and quartzite grains Calcium carbonate and caliche were present The estimated porosity of the clayey siltstone was low (less than 10 percent)

Outcropping sandstones (approximately 20-feet thick) occur at elevations from 5,880 to 5 860 feet MSL on the hillside south of IHSS 216 1, near Ponds B-3 and B-4 These outcrops appear to be Arapahoe No 1 Sandstone based on elevation and lithologic similarities to No 1 Sandstone identified in adjacent areas Two other sandstone outcrops located northwest and northeast of IHSS 216 1 also correlate to the Arapahoe No 1 Sandstone based on the projected dip of bedrock from previously identified occurrences of Arapahoe No 1 sandstone (DOE 1993d)

3 9 10 3 Hydrogeology

IHSS 216 1 is located on an east-northeast trending ridge between North Walnut and South Walnut Creeks where no hydrogeologic data are available The ridge is capped by RFA (Plate 3 5-2) and it is believed that the surface deposits in the IHSS are largely unsaturated This is based on the observations at well 75892 located southwest and upgradient of IHSS 216 1 Well 75892 screened in RFA is consistently dry UHSU groundwater flow may occur in weathered bedrock to the east-northeast along the ridge or may discharge to colluvium mantling the hillsides of the mesa Groundwater discharged to colluvium would likely evapotranspirate or flow to Valley-Fill Alluvium in either the North Walnut or South Walnut Creek drainages

3 9 10 4 Surface Water

Based on topography, surface water runoff from IHSS 216 1 drains to the northeast and southeast toward the North Walnut Creek and South Walnut Creek This IHSS is located along the divide between drainage sub-basins WA11 and SWA3 (Figure 3 7-1), which have low to moderate infiltrative soils (Table 3 9-1) Sub-basins WA11 and SWA3 are 5 percent and 3 percent impervious respectively

TABLE 3 2-1
SUMMARY OF POPULATION SECTORS IN AND NEAR THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

Sector	1989 Population	1989 Household No	2010 Population	2010 Household No.
1	0	0	0	0
2	0	0	0	0
3	51	15	51	17
4	633	193	2 263	950
5	8 439	2 508	23 773	9 957
10	307 567	109 859	408 821	171 141

Source DOE 1990b

Sector = number of miles representing radius from the center of RFETS

TABLE 3.3-1
1993 ANNUAL CLIMATIC SUMMARY

	Temperature(1) (°F)			Dewpoint (°F)	Precipitation (inches)	Wind Data (mph)		Pressure (mbars)
	High	Low	Mean	Mean	Total	Mean	Maximum	Mean
January	38 3	17 7	28 0	5 9	0 13	8 5	75	808
February	32 1	16 7	24 4	6 1	0 54	6 7	70	808
March	47 9	28 0	38 0	13 3	1 52	9 2	50	811
Apnl	53 5	31 2	42 4	(2)	1 45	9 3	67	808
May	64 9	42 4	53 7	(2)	1 13	7 9	60	813
June	72 7	48 0	60 4	35 1	1 79	8 5	58	812
July	79 7	54 0	66 8	40 5	0 48	8 9	73	814
August	75 4	53 6	64 5	40 9	0 42	7 5	47	817
September	68 7	49 0	58 8	31 6	1 58	8 2	58	(2)
October	58 9	32 1	45 5	29 3	1 41	7 6	66	814
November	45 0	19 7	32 4	15 2	1 27	9 8	66	811
December	45 6	20 6	33 1	11 5	0 35	12 3	82	810

Source DOE 1993a

Notes

(1) Temperatures were measured at 10 meters (m) above the ground surface through August and at 1 5 m above the ground surface beginnmg September 1 1993

(2) Data mvalid or not available

TABLE 3 3 2
ROCKY FLATS
WIND FREQUENCY DISTRIBUTION BY PERCENT IN 1993

STABILITY INDEX A[a]

FROM JANUARY 1, 1993 THROUGH DECEMBER 31, 1993

	+ WIND SPEED CLASSES (KNOTS) +							
DIRECTION	<3 0	3 0 <6 0	6 0 <10 0	10 0 <16 0	16 0 <=21 0	>21 0	Class[b]	TOTAL[c]
N	1 9	5 9	0 0	0 0	0 0	0 0	7 83	73
NNE	2 3	6 8	0 0	0 0	0 0	0 0	9 03	84
NE	2 0	8 2	0 0	0 0	0 0	0 0	10 15	94
ENE	2 1	7 9	0 0	0 0	0 0	0 0	9 97	92
E	2 5	10 2	0 0	0 0	0 0	0 0	12 75	1 18
ESE	2 8	10 6	0 0	0 0	0 0	0 0	13 38	1 24
SE	2 2	10 2	0 0	0 0	0 0	0 0	12 41	1 15
SSE	2 0	5 0	0 0	0 0	0 0	0 0	7 02	65
S	1 1	2 9	0 0	0 0	0 0	0 0	4 04	37
SSW	1 0	1 2	0 0	0 0	0 0	0 0	2 13	20
SW	5	7	0 0	0 0	0 0	0 0	1 19	11
WSW	5	7	0 0	0 0	0 0	0 0	1 22	11
W	6	8	0 0	0 0	0 0	0 0	1 44	13
WNW	9	9	0 0	0 0	0 0	0 0	1 79	17
NW	9	1 2	0 0	0 0	0 0	0 0	2 10	19
NNW	1 5	2 1	0 0	0 0	0 0	0 0	3 54	33
TOTAL	24 7	75 3	0 0	0 0	0 0	0 0	100 00	9 26

[a]Total number of hourly samples in this stability class is 809
[b]Total percent for this stability class
[c]Total percent relative to all stability classes

Stability Index ranges from A(extremely unstable) to F(moderately stable)
D = Neutral stability with respect to wind direction
Data from DOE 1993a

Note Analysis of data performed by computer program based on algorithms presented in U S EPA 1987 On site Meteorological Program Guidance for Regulatory Modeling Application

TABLE 3 3-2 (continued)
ROCKY FLATS
WIND FREQUENCY DISTRIBUTION BY PERCENT IN 1993
(WIND SPEED, DIRECTION, AND STABILITY)

STABILITY INDEX B[a]

FROM JANUARY 1, 1993 THROUGH DECEMBER 31, 1993

+ - - WIND SPEED CLASSES (KNOTS)-- --+

DIRECTION	<3 0	3 0-<6 0	6 0-<10 0	10 0 <16 0	16 0 <21.0	>=21 0	Class[b]	TOTAL[c]
N	7	3 7	6 1	0 0	0 0	0 0	10 44	63
NNE	7	5 1	5 9	0 0	0 0	0 0	11 73	71
NE	6	4 4	5 0	0.0	0 0	0.0	9 97	60
ENE	3	3 3	3 5	0 0	0 0	0 0	7 06	42
E	4	3 6	4 1	0 0	0 0	0 0	8 20	49
ESE	.5	6 4	6.2	0 0	0 0	0 0	13 02	78
SE	6	6 3	7 9	0 0	0 0	0 0	14 73	89
SSE	5	4 2	4.5	0 0	0 0	0 0	9.25	56
S	1	2 0	1 6	0 0	0 0	0 0	3 63	22
SSW	3	8	6	0 0	0 0	0 0	1 72	10
SW	0	3	4	0 0	0 0	0 0	67	04
WSW	1	2	7	0 0	0 0	0 0	1 05	06
W	2	2	7	0 0	0 0	0 0	1 14	07
WNW	1	.2	1 1	0 0	0 0	0 0	1 48	09
NW	3	3	1 0	0 0	0.0	0 0	1 62	10
NNW	6	1 4	2 3	0 0	0 0	0 0	4 29	26
TOTAL	5 9	42 5	51 5	0 0	0 0	0 0	100 00	6 01

[a]Total number of hourly samples in this stability class is 525
[b]Total percent for this stability class
[c]Total percent relative to all stability classes

Stability Index ranges from A (extremely unstable) to F (moderately stable)
D = Neutral stability with respect to wind direction
Data from DOE 1993a

Note Analysis of data performed by computer program based on algorithms presented in U.S EPA 1987 On-site Meteorological Program Guidance for Regulatory Modeling Application

TABLE 3 3 2 (continued)
ROCKY FLATS
WIND FREQUENCY DISTRIBUTION BY PERCENT IN 1993

STABILITY INDEX C[a]

FROM JANUARY 1, 1993 THROUGH DECEMBER 31, 1993

		+	WIND SPEED CLASSES (KNOTS)		+			
DIRECTION	**<3 0**	**3 0 <6 0**	**6 0 <10 0**	**10 0 <16 0**	**16 0 <21 0**	**>=21 0**	**Class[b]**	**TOTAL[c]**
N	4	2 5	8 6	2 2	0 0	0 0	13 74	1 21
NNE	5	2 9	6 5	1 0	0 0	0 0	10 82	95
NE	2	3 1	4 3	6	0 0	0 0	8 22	72
ENE	3	1 9	2 2	4	0 0	0 0	4 84	43
E	4	2 6	2 1	2	0 0	0 0	5 27	46
ESE	2	2 5	4 3	1	0 0	0 0	7 15	63
SE	4	3 7	6 4	8	0 0	0 0	11 34	1 00
SSE	2	2 5	6 7	8	0 0	0 0	10 30	91
S	3	1 3	1 5	2	0 0	0 0	3 32	29
SSW	1	5	7	3	0 0	0 0	1 56	14
SW	2	3	7	2	0 0	0 0	1 46	13
WSW	1	2	7	9	0 0	0 0	1 98	17
W	1	3	1 8	1 6	0 0	0 0	3 80	33
WNW	2	3	2 2	2 1	0 0	0 0	4 84	43
NW	3	7	1 9	1 2	0 0	0 0	4 19	37
NNW	3	1 7	3 9	1 3	0 0	0 0	7 18	63
TOTAL	4 3	27 0	54 7	14 0	0 0	0 0	100 00	8 81

[a]Total number of hourly samples in this stability class is 770
[b]Total percent for this stability class
[c]Total percent relative to all stability classes

Stability Index ranges from A (extremely unstable) to F (moderately stable)
D = Neutral stability with respect to wind direction
Data from DOE 1993a

Note Analysis of data performed by computer program based on algorithms presented in U S EPA 1987 On site Meteorological Program Guidance for Regulatory Modeling Application

TABLE 3 3 2 (continued)
ROCKY FLATS
WIND FREQUENCY DISTRIBUTION BY PERCENT IN 1993

STABILITY INDEX D[a]

FROM JANUARY 1, 1993 THROUGH DECEMBER 31, 1993

+ - ---WIND SPEED CLASSES (KNOTS)-- - --+

DIRECTION	<3 0	3 0 <6 0	6 0-<10 0	10 0-<16 0	16 0-<21 0	>=21 0	Class[b]	TOTAL[c]
N	2	1 3	2 9	2 5	3	0 0	7 34	3 17
NNE	3	1 4	1 8	1 2	1	0 0	4 76	2 05
NE	3	1 1	1 2	7	0 0	0 0	3 26	1 41
ENE	2	9	8	2	0 0	0 0	2 04	88
E	1	7	7	2	0 0	0 0	1 68	73
ESE	1	7	6	2	0 0	0 0	1 54	67
SE	1	1 0	1 7	4	0 0	0 0	3 26	1 41
SSE	2	1 2	2 5	1 0	0 0	0 0	4 92	2 12
S	2	1 4	2 0	9	1	0 0	4 54	1 96
SSW	2	1 5	1 9	8	1	0 0	4 55	1 97
SW	2	1 2	1 9	1 4	1	0 0	4 76	2 06
WSW	3	1 1	1 8	2 5	7	3	6 77	2 93
W	2	1 7	2 1	4 1	2.2	2 6	12 99	5 61
WNW	4	2 1	2 7	6 7	3 7	4 2	19 72	8 52
NW	3	2 0	2 6	3 0	1 0	7	9 63	4 16
NNW	3	1 7	3 6	2 4	0 2	1	8 24	3 56
TOTAL	3 5	21 1	30 7	28 2	8 6	8 0	100 00	43 19

[a]Total number of hourly samples in this stability class is 3774
[b]Total percent for this stability class
[c]Total percent relative to all stability classes

Stability Index ranges from A (extremely unstable) to F (moderately stable)
D = Neutral stability with respect to wind direction
Data from DOE 1993a

Note Analysis of data performed by computer program based on algorithms presented in U S EPA 1987 On-site Meteorological Program Guidance for Regulatory Modeling Application

TABLE 3 3 2 (continued)
ROCKY FLATS
WIND FREQUENCY DISTRIBUTION BY PERCENT IN 1993

STABILITY INDEX E[a]

FROM JANUARY 1 1993 THROUGH DECEMBER 31, 1993

	+ WIND SPEED CLASSES (KNOTS) +							
DIRECTION	**<3 0**	**3 0 <6 0**	**6 0 <10 0**	**10 0 <16 0**	**16 0 <21 0**	**>=21 0**	**Class[b]**	**TOTAL[c]**
N	7	2 4	1 9	2	0 0	0 0	5 24	1 11
NNE	9	2 1	2 5	3	0 0	0 0	5 83	1 24
NE	5	1 5	1 1	1	0 0	0 0	3 21	68
ENE	5	1 7	9	1	0 0	0 0	3 21	68
E	2	1 1	8	1	0 0	0 0	2 09	44
ESE	2	7	4	0 0	0 0	0 0	1 33	28
SE	1	1 2	9	0 0	0 0	0 0	2 29	49
SSE	5	1 9	2 6	1	0 0	0 0	5 02	1 07
S	5	3 2	4 7	1	0 0	0 0	8 47	1 80
SSW	7	3 1	3 8	1	0 0	0 0	7 65	1 62
SW	5	3 5	6 1	0 0	0 0	0 0	10 05	2 13
WSW	7	3 5	6 6	0 0	0 0	0 0	10 77	2 29
W	8	4 0	2 0	0 0	0 0	0 0	6 79	1 44
WNW	8	4 5	2 9	0 0	0 0	0 0	8 20	1 74
NW	8	4 2	4 7	1	0 0	0 0	9 69	2 06
NNW	8	3 2	5 9	2	0 0	0 0	10 16	2 16
TOTAL	9 2	41 7	47 8	1 3	0 0	0 0	100 00	21 22

[a]Total number of hourly samples in this stability class is 1854
[b]Total percent for this stability class
[c]Total percent relative to all stability classes

Stability Index ranges from A (extremely unstable) to F (moderately stable)
D = Neutral stability with respect to wind direction
Data from DOE 1993a

Note Analysis of data performed by computer program based on algorithms presented in U S EPA 1987 On site Meteorological Program Guidance for Regulatory Modeling Application

TABLE 3 3 2 (continued)
ROCKY FLATS
WIND FREQUENCY DISTRIBUTION BY PERCENT IN 1993

STABILITY INDEX F[a]

FROM JANUARY 1, 1993 THROUGH DECEMBER 31, 1993

	+ WIND SPEED CLASSES (KNOTS)--------+							
DIRECTION	**<3 0**	**3 0 <6 0**	**6 0-<10 0**	**10 0-<16 0**	**16 0-<21 0**	**>=21 0**	**Class[b]**	**TOTAL[c]**
N	2 9	4 3	0 0	0 0	0 0	0 0	7 16	82
NNE	2 1	2 3	0 0	0 0	0 0	0 0	4 42	.51
NE	2 2	1 9	0 0	0 0	0 0	0 0	4 11	47
ENE	1 7	1 7	0 0	0 0	0 0	0 0	3 49	40
E	1 7	1 6	0 0	0 0	0 0	.0 0	3.28	38
ESE	1.5	1 7	0 0	0 0	0 0	0 0	3 15	36
SE	2.2	2 3	0 0	0 0	0 0	0 0	4.55	52
SSE	2 1	3 0	0 0	0 0	0 0	0 0	5 07	.58
S	2 5	3 5	0 0	0 0	0 0	0 0	6 06	70
SSW	2 5	4 6	0 0	0 0	0 0	0 0	7 10	82
SW	2 9	4 6	0 0	0 0	0 0	0 0	7 52	86
WSW	3 2	5 8	0 0	0 0	0 0	0 0	9 05	1 04
W	3 4	4 9	0 0	0 0	0 0	0 0	8 28	95
WNW	3 7	5 1	0 0	0 0	0 0	0 0	8 82	1 01
NW	3 7	5.3	0 0	0 0	0 0	0 0	8 98	1 03
NNW	3 5	5 4	0 0	0 0	0.0	0 0	8 95	1 03
TOTAL	41 9	58 1	0 0	0 0	0 0	0 0	100 00	11 48

[a]Total number of hourly samples in this stability class is 1003
[b]Total percent for this stability class
[c]Total percent relative to all stability classes

Stability Index ranges from A (extremely unstable) to F (moderately stable)
D = Neutral stability with respect to wind direction
Data from DOE 1993a

Note Analysis of data performed by computer program based on algorithms presented in U S EPA 1987 On-site Meteorological Program Guidance for Regulatory Modeling Application

TABLE 3 3 2 (concluded)
ROCKY FLATS
WIND FREQUENCY DISTRIBUTION BY PERCENT 1993

STABILITY INDEX ALL

FROM JANUARY 1, 1993 THROUGH DECEMBER 31, 1993

	+ WIND SPEED CLASSES (KNOTS) +							
DIRECTION	**<3 0**	**3 0 <6 0**	**6 0 <10 0**	**10 0 <16 0**	**16 0 <21 0**	**>=21 0**	**Class[b]**	**TOTAL[c]**
N	9	2 5	2 8	1 3	1	0 0	7 67	7 67
NNE	9	2 5	2 2	7	0 0	0 0	6 30	6 29
NE	7	2 3	1 4	4	0 0	0 0	4 82	4 82
ENE	6	2 1	9	1	0 0	0 0	3 74	3 74
E	6	2 1	9	1	0 0	0 0	3 69	3 68
ESE	5	2 2	1 1	1	0 0	0 0	3 96	3 96
SE	6	2 6	2 0	3	0 0	0 0	5 45	5 45
SSE	7	2 2	2 5	5	0 0	0 0	5 89	5 89
S	6	2 2	2 1	4	0 0	0 0	5 34	5 34
SSW	6	2 0	1 7	4	0 0	0 0	4 84	4 84
SW	6	1 9	2 2	6	0 0	0 0	5 33	5 33
WSW	7	2 0	2 3	1 2	3	1	6 60'	6 60
W	7	2 3	1 5	1 9	1 0	1 1	8 54	8 54
WNW	9	2 6	2 0	3 1	1 6	1 8	11 96	11 95
NW	9	2 6	2 3	1 4	4	3	7 91	7 91
NNW	9	2 5	3 3	1 2	1	1	7 96	7 96
TOTAL	11 3	36 5	31 4	13 7	3 7	3 5	100 00	99 97

[a]Total Number of hourly samples in all stability classes is 8736
[b]Total percent for this stability class
[c]Total percent relative to all stability classes Annual data recovery = 99 9 percent
Number of Hours of Data 8808

Stability Index ranges from A (extremely unstable) to F (moderately stable)
D = Neutral stability with respect to wind direction
Data from DOE 1993a

Note Analysis of data performed by computer program based on algorithms presented in U S EPA 1987 On site Meteorological Program Guidance for Regulatory Modeling Application

TABLE 3 4-1
SOIL UNITS WITHIN THE OU6 AREA

Series	Family	Phase	Minimum-Maximum Slope (%)	Location (ie. hillside, ridge, etc.)	Infiltration Rate	Permeability	Water Capacity	Water Erosion Hazard	Shrink-Swell Potential
Denver Kutch-Midway	Torretic Argiustolls	clay loam	9-25	hillsides ridge	slow	slow	high/low	severe	high
Flatirons	Aridic Paleustolls	very cobbly sandy loam	0-3	ridges	slow	slow	low	slight	moderate
Denver	Torretic Argiustolls	clay loam	5 9	hillside	slow	slow	high	severe	high
Nederland	Aridic Argiustolls	very cobbly sandy loam	15 50	ridges hillsides	moderate	moderate	moderate	severe	low
Haverson	Ustic Torrifluventis	loam	0 3	flood plain	slow	moderate/ slow	high	slight	low
Englewood	Torretic Argiustolls	clay loam	0-2	flood plain	slow	slow	high	slight	high
Englewood	Torretic Argiustolls	clay loam	2-5	flood plain	slow	slow	high	moderate	high
Leyden Primen Standley	Aridic Argiustolls	cobbly clay loam	15-50	hillsides	slow	slow	low/high	severe	moderate to high
Valmont	Aridic Argiustolls	clay loam	0-3	ridges	slow	slow to moderate	moderate	slight	high/low

Source Department of Agriculture (1980)

TABLE 3 5-1
OU6 PHASE I STRATIGRAPHIC DATA

Site Number	State Plane Coordinates Easting	State Plane Coordinates Northing	IHSS Location	Ground Surface Elevation (ft MSL)	Top of Bedrock Depth (ft BGS)	Top of Bedrock Elevation (ft BGS)	Bedrock Lithology	Thickness of Surface Deposits (ft)	Total Depth Depth (ft BGS)	Total Depth Lithology at Total Depth	Stratigraphy of Screened Interval
Sludge Dispersal Area											
75992	2086628	750290	141	5897 1	10 0	5887 1	claystone	10 0	15 5	claystone	Qc
Pond A-4											
75092	2089870	753228	142 4	5723 4	6 3	5717 1	claystone	6 3	16 7	claystone	Kl
Pond B-5											
75292	2089809	752305	142 9	5754 9	7 6	5747 3	claystone	7 6	13 6	claystone	Qvf
Old Outfall Area											
60092	2083494	751231	143	5941 9	NE	NE	NA	Unknown	10 2	af/Qrf	NA
60192	2083520	751228	143	5942 2	NE	NE	NA	Unknown	11 9	af/Qrf	NA
60292	2083496	751241	143	5942 1	NE	NE	NA	Unknown	13 9	af/Qrf	NA
60392	2083508	751237	143	5941 9	NE	NE	NA	Unknown	10 0	af/Qrf	NA
60492	2083496	751246	143	5942 0	NE	NE	NA	Unknown	11 8	af/Qrf	NA
60692	2083307	750924	143	5941 4	5 3	5936 1	claystone	5 3	10 0	claystone	NA
77492	2083508	751246	143	5942 0	22 5	5919 5	claystone	22 5	24 1	claystone	Qrf
Soil Dump Area											
63592	2086336	750971	156 2	5952 8	16 6	5936 2	claystone	16 6	20 1	claystone	NA
63692	2086252	751032	156 2	5937 0	12 8	5923 3	claystone	13 8	14 0	claystone	NA
73592	2086447	751004	156 2	5954 6	13 0	5941 6	claystone	13 0	22 0	claystone	NA
73692	2086514	750889	156 2	5953 5	6 0	5947 5	claystone	6 0	24 6	claystone	NA
73792	2086591	750761	156 2	5953 3	4 9	5948 4	sandstone	4 9	9 9	claystone	NA
73892	2086588	751059	156 2	5952 8	16 3	5936 5	claystone	16 3	18 0	claystone	NA
73992	2086658	750935	156 2	5955 5	10 3	5945 2	claystone	10 3	14 0	claystone	NA
74092	2086734	750803	156 2	5954 4	10 3	5944 1	claystone	10 3	18 0	claystone	NA
74192	2086671	751026	156 2	5953 2	17 4	5935 8	claystone	17 4	18 0	claystone	NA
74292	2086716	751116	156 2	5954 1	20 1	5934 0	claystone	20 1	24 3	claystone	NA
74392	2086798	750991	156 2	5953 1	9 8	5943 3	claystone	9 8	12 9	claystone	NA
74492	2086872	750860	156 2	5949 4	8 0	5941 4	claystone	8 0	14 2	claystone	NA
74592	2086832	751088	156 2	5954 5	23 1	5931 4	claystone	23 1	24 0	claystone	NA
74692	2086910	750960	156 2	5951 1	8 3	5942 8	claystone	8 3	12 2	claystone	NA
74792	2086861	751175	156 2	5952 0	22 6	5929 4	claystone	22 6	24 2	claystone	NA

TABLE 3 5-1
OU6 PHASE I STRATIGRAPHIC DATA

Site Number	State Plane Coordinates Easting	State Plane Coordinates Northing	IHSS Location	Ground Surface Elevation (ft MSL)	Top of Bedrock Depth (ft BGS)	Top of Bedrock Elevation (ft BGS)	Bedrock Lithology	Thickness of Surface Deposits (ft)	Total Depth Depth (ft BGS)	Total Depth Lithology at Total Depth	Stratigraphy of Screened Interval
74892	2086925	751062	156 2	5951 3	NE	NE	NA	Unknown	14 0	Qrf	NA
74992	2086952	751152	156 2	5951 8	15 8	5936 0	claystone	15 8	22 0	claystone	NA
75892	2086558	750915	156 2	5956 2	7 6	5948 6	claystone	7 6	14 6	claystone	Qrf
77592	2087016	751049	156.2	5949 6	10 2	5939 4	claystone	10 2	13/3	claystone	NA
77692	2087055	751148	156.2	5952 1	14 8	5937 3	claystone	14 8	19 5	claystone	NA
77792	2087076	751255	156 2	5947 5	14 2	5933 3	sandstone	14.2	24 4	claystone	NA
77892	2087132	751155	156 2	5950 3	14 3	5936.0	sandstone	14 3	18 7	claystone	NA
77992	2087177	751233	156 2	5946 0	NE	NE	NA	Unknown	12 0	Qrf	NA
Triangle Area											
72292	2085420	750421	165	5963 5	12 1	5951 4	sandstone	12 1	16 4	sandstone	NA
72392	2085651	750432	165	5959 4	12 6	5946 8	claystone	12 6	16 0	claystone	NA
72492	2085770	750475	165	5958 2	NE	NE	NA	Unknown	5 0	af/Qrf	NA
72592	2085417	750523	165	5963 3	NE	NE	NA	Unknown	5 0	af/Qrf	NA
72692	2085541	750523	165	5961 5	NE	NE	NA	Unknown	4 0	af/Qrf	NA
72792	2085640	750520	165	5959 9	20 7	5939 2	siltstone	20 7	23 8	siltstone	NA
72892	2085772	750540	165	5959 3	10 6	5948 7	sandstone	10 6	12 4	sandstone	NA
72992	2085530	750625	165	5961 5	6 2	5955.3	claystone	6 2	15 0	claystone	NA
73092	2085508	750720	165	5960 1	4 7	5955 4	claystone	4 7	12 0	claystone	NA
73292	2085764	750733	165	5957 4	NE	NE	NA	Unknown	4 0	af/Qrf	NA
73392	2085856	750738	165	5954 9	6 4	5948 5	sandstone	6 4	12.0	sandstone	NA
73492	2085758	750840	165	5954 4	8 1	5946 3	sandstone	8 1	13 0	sandstone	NA
76192	2086122	750660	165	5960 0	6.0	5954 0	claystone	6 0	14 0	claystone	Qrf
76292	2085681	750769	165	5957 0	8.5	5948 5	sandstone	8 5	21 2	sandstone	Ka
Trench A											
66892	2083922	752425	166 1	5971 2	8 4	5962 8	claystone	8.4	12 3	claystone	NA
66992	2083945	752429	166 1	5971 5	10 6	5960 9	claystone	10 6	12 0	claystone	NA
67092	2083971	752434	166 1	5968 9	7 1	5961 8	claystone	7 1	13 3	claystone	NA
67192	2083998	752439	166 1	5967 7	5 0	5962 7	claystone	5 0	12 5	claystone	NA
67292	2084020	752443	166 1	5967 6	5 3	5962 3	claystone	5 3	12 0	claystone	NA
67392	2084046	752448	166 1	5968 0	5 9	5962 1	claystone	5 9	12 5	claystone	NA

TABLE 3 5-1
OU6 PHASE I STRATIGRAPHIC DATA

Site Number	State Plane Coordinates Easting	State Plane Coordinates Northing	IHSS Location	Ground Surface Elevation (ft MSL)	Top of Bedrock Depth (ft BGS)	Top of Bedrock Elevation (ft BGS)	Top of Bedrock Bedrock Lithology	Thickness of Surface Deposits (ft)	Total Depth Depth (ft BGS)	Total Depth Lithology at Total Depth	Stratigraphy of Screened Interval
67492	2084068	752451	166 1	5968 1	6 7	5961 4	claystone	6 7	12 4	claystone	NA
68292	2083903	752403	166 1	5971 0	9 9	5961 1	claystone	9 9	12 4	claystone	NA
Trench B											
67592	2083853	752201	166 2	5972 3	8 0	5964 3	claystone	8 0	12 2	claystone	NA
67692	2083876	752207	166 2	5971 3	8 5	5962 8	claystone	8 5	11 9	claystone	NA
67792	2083904	752212	166 2	5970 4	5 7	5964 7	claystone	5 7	12 1	claystone	NA
67892	2083928	752216	166 2	5970 4	5 8	5964 6	claystone	5 8	12 0	claystone	NA
67992	2083953	752220	166 2	5970 4	6 0	5964 6	claystone	5 8	10 2	claystone	NA
68092	2083979	752225	166 2	5969 8	5 8	5964 0	claystone	5 8	12 1	claystone	NA
68192	2084001	752228	166 2	5971 4	NE	NE	NA		13 0	Qrf	NA
77392	2084299	752243	166 2	5962 5	7 0	5955 5	claystone	7 0	13 8	claystone	Qrf
Trench C											
68392	2083872	752302	166 3	5972 8	10 2	5962 6	NA	10 2	12 3	Qrf	NA
68492	2083898	752308	166 3	5971 5	8 4	5963 1	claystone	8 4	12 1	claystone	NA
68592	2083924	752315	166 3	5970 6	8 3	5962 3	claystone	8 3	12 0	claystone	NA
68692	2083946	752319	166 3	5970 4	8 0	5962 4	siltstone	8 0	12 0	siltstone	NA
68792	2083973	752324	166 3	5970 8	8 0	5962 8	siltstone	8 0	12 3	siltstone	NA
68892	2083999	752327	166 3	5970 4	8 3	5962 1	siltstone	8 3	12 0	siltstone	NA
68992	2084328	752532	166 3	5964 9	6 2	5958 7	claystone	6 2	12 1	claystone	NA
69092	2084352	752533	166 3	5964 4	6 2	5958 2	claystone	6 2	12 2	claystone	NA
69192	2084380	752536	166 3	5963 6	10 1	5953 5	claystone	10 1	12 1	claystone	NA
69292	2084402	752537	166 3	5962 8	6 4	5956 4	claystone	6 4	12 1	claystone	NA
69392	2084427	752540	166 3	5962 4	10 3	5952 1	claystone	10 3	12 2	claystone	NA
76992	2084500	752561	166 3	5955 0	9 6	5945 4	claystone	9 6	15 5	claystone	Qrf
North Spray Field Area											
61192	2083890	753838	167 1	5965 9	NE	NE	NA	Unknown	4 0	Qrf	NA
61292	2083779	753780	167 1	5964 4	NE	NE	NA	Unknown	4 0	Qrf	NA
61392	2083892	753784	167 1	5961 8	NE	NE	NA	Unknown	4 0	Qrf	NA
61492	2083996	753789	167 1	5958 9	NE	NE	NA	Unknown	4 0	Qrf	NA
61692	2083891	753681	167 1	5966 5	NE	NE	NA	Unknown	4 0	Qrf	NA

TABLE 3 5-1
OU6 PHASE I STRATIGRAPHIC DATA

Site Number	State Plane Coordinates Easting	State Plane Coordinates Northing	IHSS Location	Ground Surface Elevation (ft MSL)	Top of Bedrock Depth (ft BGS)	Top of Bedrock Elevation (ft BGS)	Bedrock Lithology	Thickness of Surface Deposits (ft)	Total Depth Depth (ft BGS)	Total Depth Lithology at Total Depth	Stratigraphy of Screened Interval
61792	2083996	753678	167 1	5961 1	NE	NE	NA	Unknown	4 0	Qrf	NA
61892	2084116	753666	167 1	5949 9	NE	NE	NA	Unknown	4 0	Qrf	NA
61992	2084192	753653	167 1	5944 3	1 8	5942 5	claystone	1 8	4 0	claystone	NA
62092	2084280	753636	167 1	5926 7	0 0	5926 7	claystone	0 0	4 1	claystone	NA
62192	2083782	753577	167 1	5968 0	NE	NE	NA	Unknown	4 0	Qrf	NA
62292	2083593	753691	167 1	5970 2	NE	NE	NA	Unknown	4 0	Qrf	NA
62392	2083671	753690	167 1	5968 8	NE	NE	NA	Unknown	4 0	Qrf	NA
62492	2083781	753686	167 1	5967 8	NE	NE	NA	Unknown	4 0	Qrf	NA
62592	2083892	753574	167 1	5967 1	NE	NE	NA	Unknown	4 0	Qrf	NA
62692	2083997	753568	167 1	5963 9	NE	NE	NA	Unknown	4 0	Qrf	NA
62792	2084103	753564	167 1	5953 2	3 1	5950 1	claystone	3 1	4 4	claystone	NA
62892	2084201	753565	167 1	5940 4	NE	NE	NA	Unknown	3 8	Qrf	NA
62992	2083890	753519	167 1	5967 0	NE	NE	NA	Unknown	4 0	Qrf	NA
63092	2083673	753626	167 1	5969 7	NE	NE	NA	Unknown	4 0	Qrf	NA
63192	2083776	753626	167 1	5968.3	NE	NE	NA	Unknown	4 0	Qrf	NA
63292	2084098	753519	167 1	5981 2	NE	NE	NA	Unknown	4 3	Qrf	NA
63392	2083998	753464	167 1	5960 7	NE	NE	NA	Unknown	4 5	Qrf	NA
77192	2084381	753646	167 1	5913 9	NE	NE	NA	Unknown	11 9	Qc	Qc
Pond Spray Field Area											
64792	2084079	752800	167 2	5930 7	0 0	5930 7	siltstone	0 0	4 1	siltstone	NA
64892	2084181	752795	167 2	5930 4	2 2	5928 2	claystone	2.2	4 2	claystone	NA
64992	2084281	752803	167 2	5932 3	1 7	5930.6	siltstone	1 7	4.0	siltstone	NA
65092	2084133	752780	167 2	5934 0	NE	NE	NA	Unknown	4 0	Qc	NA
65192	2084231	752776	167 2	5935 8	NE	NE	NA	Unknown	4 0	Qc	NA
65292	2084082	752741	167 2	5935 9	1 0	5934 9	claystone	1 0	4 0	claystone	NA
65392	2084181	752747	167 2	5938 6	0 8	5937 8	claystone	0 8	4 0	claystone	NA
65492	2084281	752754	167 2	5937 7	NE	NE	NA	Unknown	4 0	Qc	NA
65592	2084131	752728	167 2	5938 6	0 4	5938 2	claystone	0 4	4 0	claystone	NA
65692	2084234	752727	167 2	5942 2	2 1	5940 1	claystone	2 1	4 0	claystone	NA
65792	2084082	752695	167 2	5937 8	0 0	5937 8	claystone	0 0	4 0	claystone	NA

TABLE 3 5-1
OU6 PHASE I STRATIGRAPHIC DATA

Site Number	State Plane Coordinates Easting	State Plane Coordinates Northing	IHSS Location	Ground Surface Elevation (ft MSL)	Top of Bedrock Depth (ft BGS)	Top of Bedrock Elevation (ft BGS)	Bedrock Lithology	Thickness of Surface Deposits (ft)	Total Depth Depth (ft BGS)	Total Depth Lithology at Total Depth	Stratigraphy of Screened Interval
65892	2084182	752701	167 2	5941 9	0 0	5941 9	claystone	0 0	4 0	claystone	NA
65992	2084282	752705	167 2	5944 8	NE	NE	NA	Unknown	4 0	Qc	NA
South Spray Field Area											
66092	2084470	752482	167 3	5960 2	NE	NE	NA	Unknown	4 0	Qrf	NA
66192	2084618	752455	167 3	5958 9	NE	NE	NA	Unknown	4 0	Qrf	NA
66292	2084538	752409	167 3	5961 2	NE	NE	NA	Unknown	4 0	Qrf	NA
66392	2084671	752434	167 3	5958 5	NE	NE	NA	Unknown	4 0	Qrf	NA
66492	2084467	752364	167 3	5963 2	NE	NE	NA	Unknown	4 0	Qrf	NA
66592	2084603	752366	167 3	5961 6	NE	NE	NA	Unknown	4 0	Qrf	NA
66692	2084536	752323	167 3	5962 9	NE	NE	NA	Unknown	4 0	Qrf	NA
66792	2084674	752333	167 3	5961 2	NE	NE	NA	Unknown	4 0	Qrf	NA
76792	2084618	752546	167 3	5943 5	6 3	5937 2	claystone	6 3	12 2	claystone	Qrf
East Spray Field Area											
78092	2087565	751384	216 1	5924 8	3 1	5921 7	siltstone	3 1	4 0	siltstone	NA
78192	2087768	751238	216 1	5919 9	NE	NE	NA	Unknown	4 0	Qrf	NA
78292	2087756	751444	216 1	5917 6	NE	NE	NA	Unknown	4 0	Qrf	NA
78392	2087573	751187	216 1	5923 2	NE	NE	NA	Unknown	4 0	Qrf	NA
78492	2087970	751472	216 1	5912 3	NE	NE	NA	Unknown	4 0	Qrf	NA
78592	2087963	751287	216 1	5911 3	NE	NE	NA	Unknown	4 0	Qrf	NA

Explanation

IHSS Individual Hazardous Substance Site
af artificial fill (man-made deposits)
Qc-Quaternary colluvium
Qrf Quaternary Rocky Flats Alluvium
Qvf Quaternary Valley Fill Alluvium
Kl Cretaceous Laramie Formation

BGS Below Ground Surface
MSL-Mean Sea Level
NA not applicable
NE- not encountered

TABLE 3.5-2
HISTORICAL BORING AND MONITORING WELL INFORMATION INCLUDING STRATIGRAPHIC DATA

New Site Number	True State Plane Coordinates (1) Easting (ft)	Northing (ft)	Well Type/ Boring	Stratigraphy of Screened Interval	Ground Surface Elevation (1) (2) (ft AMSL)	Well Casing Stickup (ft AGS)	Top of Well Casing Elevation (ft AMSL)	Screened Interval Depth (ft BGS)	Screened Interval Elevation (ft AMSL)	Top of Bedrock (3) Depth (ft BGS)	Top of Bedrock (3) Elevation (ft AMSL)	Alluvial Thickness (ft)	Boring Total Depth (ft BGS)
Landfill													
786	2083977	752827	Alluvial	Qvf	5924.94	1.6	5926.5	3.0-5.7	5921.9-5919.2	5.0	5919.94	5.0	10.0
886	2084001	752817	Bedrock	K (clst/sltst)	5925.60	1.3	5926.9	59.1-63.8	5866.5-5861.8	1.0	5924.60	1.0	71.5
*6087	2083035	752930	Alluvial	Qrf	5984.44	1.5	5986.0	3.5-27.5	5980.9-5956.9	No Log	Unknown	Unknown	32.0
*6187	2083072	752860	Alluvial	Qrf	5984.42	1.4	5985.8	3.5-28.2	5980.9-5956.2	No Log	Unknown	Unknown	34.0
*6287	2083097	752800	Alluvial	Qrf	5984.54	1.8	5986.4	3.5-26.6	5981.0-5957.9	No Log	Unknown	Unknown	30.0
6387A	2083138	752717	Alluvial	Qrf	5985.63	1.4	5987.0	3.54-25.4	5982.1-5960.2	25.0	5960.63	25.0	30.0
6487	2083261	752329	Alluvial	Qrf	5986.09	1.3	5987.3	13.0-23.3	5973.1-5962.8	22.0	5964.09	22.0	28.0
6587	2083299	752230	Alluvial	Qrf	5983.48	1.5	5985.0	10.7-24.0	5972.8-5959.5	21.0	5962.48	21.0	27.0
6687	2083325	752150	Alluvial	Qrf	5982.26	1.4	5983.7	3.4-18.0	5978.9-5964.3	15.3	5966.96	15.3	23.0
6787A	2083774	753164	Alluvial	Qrf	5970.00	1.8	5971.8	11.7-16.5	5958.3-5953.5	16.4	5953.60	16.4	21.4
6887	2083776	753145	Alluvial	Qrf	5968.91	1.4	5970.3	11.2-15.8	5957.5-5953.1	15.6	5953.31	15.6	20.0
7087	2084196	752571	Alluvial	Qrf	5966.71	1.7	5968.4	3.5-16.3	5963.2-5950.4	12.0	5954.71	12.0	17.0
7187	2084087	753322	Alluvial	Qrf	5963.89	1.6	5965.5	3.5-13.5	5960.4-5950.4	14.0	5949.89	14.0	18.5
7287	2083953	752441	Alluvial	Qrf	5969.60	1.6	5971.3	3.5-6.8	5966.1-5962.8	8.0	5961.60	8.0	15.0
44492	2083405	752450	Alluvial	af	5985.50	(4)	(4)	7.6-11.6	5977.9-5973.9	18.3	5967.20	18.3	27.0
B206189A	2083301	752332	Bedrock	K(clst)	5984.50	2.1	5986.6	25.9-35.4	5958.6-5949.1	21.0	5963.50	21.0	45.0
B206289	2083564	752253	Bedrock	K(clst)	5977.59	1.9	5979.5	32.4-41.8	5945.2-5935.8	15.0	5962.59	15.0	47.5
B206389A	2083926	752548	Alluvial	Qrf	5969.70	1.9	5971.6	4.0-13.5	5965.7-5956.2	13.3	5956.40	13.3	20.0
B206489	2083964	752427	Alluvial	Qrf/K(clst)	5969.14	2.4	5971.5	3.3-10.0	5965.8-5959.1	7.3	5961.84	7.3	41.5
B206589	2084121	752458	Bedrock	K(clst)	5967.80	1.9	5969.7	23.5-35.2	5944.3-5932.6	7.5	5960.30	7.5	41.5
B206689	2084361	752588	Bedrock	K(clst)	5959.31	1.9	5961.2	8.7-18.2	5950.6-5941.1	3.7	5955.61	3.7	21.7
B206789	2084161	752818	Bedrock	K(clst)	5927.90	2.3	5930.2	9.8-19.3	5918.1-5908.6	4.8	5923.10	4.8	30.0
B206889	2084781	752823	Bedrock	K(clst)	5917.09	2.1	5919.2	8.0-17.5	5909.1-5899.6	3.0	5914.09	3.0	19.5
B207289	2084360	753267	Bedrock	K(clst)	5948.27	2.2	5950.5	5.2-14.7	5943.1-5933.6	0.2	5948.07	0.2	19.5
Protected Area (PA)													
1986	2083296	750894	Alluvial	Qvf	5931.22	1.3	5932.5	3.0-12.3	5919.0-5928.2	13.7	5917.52	13.7	16.5
2386	2084259	750338	Bedrock	K(sltst/clst)	5982.50	(4)	(4)	113.0-117.3	5868.2-5863.9	8.2	5974.30	8.2	130.5
2486	2084277	750338	Alluvial	Qrf	5980.50	(4)	(4)	3.0-7.5	5977.4-5973.0	7.2	5973.30	7.2	12.0
2786	2085238	75081	Bedrock	K(sltst/clst)	5961.86	1.7	5963.6	128.5-133.0	5833.4-5828.9	11.0	5950.90	11.0	157.0
2886A	2085240	750803	Alluvial	Qrf	5962.40	2.0	5964.4	4.0-8.6	5958.4-5953.8	8.5	5955.90	8.5	15.5
2986	2085688	750612	Alluvial	af/Qrf	5958.26	0.5	5958.8	2.8-8.8	5955.5-5949.5	8.7	5949.56	8.7	22.5
3086	2084924	751094	Bedrock	K(clst)	5956.21	1.5	5957.7	2.5-14.9	5953.71-5941.31	2.5	5954.00	2.5	16.0
3286	2084743	751050	Bedrock	K(ss)	5966.08	1.8	5967.9	114.9-125.5	5851.2-5840.6	1.0	5965.08	1.0	135.0
2187	2085799	749969	Alluvial	Qvf/K(clst)	5928.43	1.3	5929.7	3.3-10.4	5925.1-5918.0	8.0	5920.43	8.0	17.0
2287	2085822	749924	Bedrock	K(ss)	5931.18	1.6	5932.8	81.4-88.5	5849.8-5842.7	12.8	5918.38	12.8	111.0
3887	2085094	750396	Alluvial	Qrf	5972.15	1.8	5973.9	3.5-9.3	5968.7-5962.9	NA	NA	NA	14.0
3987	2085268	751081	Bedrock	K(sltst)	5946.95	1.5	5948.4	110.0-117.1	5837.0-5829.9	3.5	5943.45	3.5	138.0

TABLE 3 5-2
HISTORICAL BORING AND MONITORING WELL INFORMATION INCLUDING STRATIGRAPHIC DATA

New Site Number	True State Plane Coordinates (1) Easting (ft)	Northing (ft)	Well Type/ Boring	Stratigraphy of Screened Interval	Ground Surface Elevation (1) (2) (ft AMSL)	Well Casing Stickup (ft AGS)	Top of Well Casing Elevation (ft AMSL)	Screened Interval Depth (ft BGS)	Screened Interval Elevation (ft AMSL)	Top of Bedrock (3) Depth (ft BGS)	Top of Bedrock (3) Elevation (ft AMSL)	Alluvial Thickness (ft)	Boring Total Depth (ft BGS)
P207389	2084468	750195	Bedrock	K(ss)	5981 00	(4)	(4)	10 5 15 2	5970 5 5965 8	7 0	5974 00	7 0	23 3
P207489A	2084481	750197	Alluvial	Qrf	5980 70	(4)	(4)	2.4-7 0	5973 7 5978 3	6 5	5974 20	6 5	10 0
P207689	2085318	750398	Alluvial	Qrf	5966 12	1 6	5967 9	3 6-13 1	5962.7 5953 2	12 6	5953 72	12.6	18 2
P207789	2085343	750392	Bedrock	K(clst)	5965 88	1 9	5967 8	17 9-27 3	5948 0-5938 5	12.9	5952.98	12.9	32.3
P207889	2085343	750671	Alluvial	af/Qrf	5962 82	2 1	5964 9	3 3 7 7	5959 6-5955 1	8 5	5954 32	8 5	10 5
P207989	2085330	750671	Bedrock	K(clst)	5963 09	2.1	5965 2	11 0-20 5	5952.1 5942.6	5 8	5957 29	5 8	26 2
B217689	2086745	749629	Bedrock	K(ss)	5960 50	1 3(4)(5)	5961 8(4)(5)	98 5 102.9	5862 5857 6	22.0	5938 50	22.0	220 1
B218089	2084020	749941	Alluvial	Qrf	5985 80	(4)	(4)	3 0-7 4	5982.8-5978 4	6 0	5979 80	6 0	16 0
P208889	2085249	751086	Bedrock	K(clst)	5947 30	2.0	5949 3	87 8-96 9	5859 5 5850 4	5 5	5941 80	5 5	105 7
P208989	2084839	751044	Bedrock	K(ss/clst)	5962.53	2.0	5964 6	15 4-24 9	5947 1 5937 7	3 5	5959 03	3 5	28 6
P209489	2084634	750991	Bedrock	K(ss)	5977 98	2.1	5980 1	15 5 35 0	5962.5-5943 0	9 0	5968.98	9 0	48 0
P209589	2085286	751071	Bedrock	K(clst)	5948 17	1 8	5950 0	9 1 18 5	5939 1 5929 7	4 1	5944 07	4 1	30 3
P209689	2085514	750533	Bedrock	K(clst)	5962.63	1 8	5964 4	17 2 26 7	5945 4-5935 9	12.2	5950 43	12.2	30 2
P209789	2085481	750579	Alluvial	Qrf	5962.82	2 1	5964 9	3 0-12.5	5959 8-5950 3	12.0	5950 82	12.0	17 5
P209889	2084984	751194	Bedrock	K(clst)	5940 28	2 1	5942.4	8 9-18 3	5931 4-5922.0	3 9	5936 38	3 9	23 9
P210289A	2085223	750564	Bedrock	K(clst)	5967 03	2.2	5969 2	11 6-21 0	5955 4-5946 0	6 6	5960 43	6 6	26 0
P218389	2085648	750831	Alluvial	Qrf	5956 20	2.3	5958 5	8 1 12.5	5948 1 5943 7	12.0	5944 20	12.0	22.0
P219089	2084117	751127	Alluvial	Qrf	5949 10	0 8	5949 9	5 0-14 5	5944 1 5934 6	10 4	5938 70	10 4	20 0
P219189	2084010	751222	Colluvial	Qc	5941 20	2.0	5943 2	7 1 11 5	5934 1 5929 7	11 0	5930 20	11 0	21 0
P219489	2085651	750415	Alluvial	Qrf	5959 50	1 7	5961 2	18 5 22.9	5941 0-5936 6	22.5	5937 00	22.5	32.0
P219589	2085536	750268	Bedrock	K(clst)	5963 80	1 9	5965 7	21 3 25 7	5942.5-5938 1	17 2	5946 60	17 2	35 0
5193	2085225	750484	Alluvial	af/Qrf	5968 40	2 2	5970 6	4 4-11 4	5964 0-5957 0	12.1	5956 30	12 1	14 1
5393	2085223	750549	Bedrock	K(clst/sltst)	5967 40	2.3	5969 7	12.1 22.1	5955 3 5945 3	6 2	5961 20	6 2	24 1
North Walnut Creek Drainage													
1186A	2090010	753331	Alluvial	Qvf/K(clst)	5718 04	2.1	5720 1	3 9-10 3	5714 1 5707 7	9 5	5708 54	9 5	15 0
1286A	2087879	752335	Alluvial	Qvf	5785 88	2.1	5788 0	2.0-11 3	5783 9-5774 6	11 0	5774 88	11 0	16 0
1386	2086051	751857	Alluvial	Qvf	5837 22	2.5	5839 7	3 1-9 5	5834 1 5827 7	9 0	5828 22	9 0	15 5
1486	2085838	751856	Bedrock	K(ss/clst)	5847 51	1 9	5849 4	39 4-55 4	5808 1 5792.1	11 0	5836 51	11 0	74 5
1586	2085812	751852	Alluvial	Qvf/K(clst)	5848 43	2.2	5850 6	4 1 14 7	5844 3 5833 7	12.5	5835 93	12.5	18 0
1686	2085260	751747	Bedrock	K(sltst/clst)	5867 92	1 6	5869 6	39 1-45 1	5828 8-5822.8	7 0	5860 92	7 0	64 0
1786	2085242	751740	Alluvial	Qvf/K(clst)	5868 43	1 1	5869 6	3 7 14 0	5864 7 5854 4	12.5	5855 93	12.5	20 0
1886	2085831	751522	Alluvial	Qvf	5885 75	2.2	5888 0	3 7 7 5	5882.1 5878 3	8 0	5877 75	8 0	10 5
B208089	2085876	751143	Alluvial	Qc	5935 40	1 7	5937 1	3 4-12.9	5932.0-5922.5	12.2	5923 20	12.2	22.2
B208189	2085885	751138	Bedrock	K(clst)	5935 40	2.1	5937 5	16 9-26 3	5918 5-5909 1	11 0	5924 40	11 0	32.5
B208289	2086289	751739	Bedrock	K(clst)	5850 70	2.3	5853 0	6 0-15 4	5844 8-5835 3	0 8	5849 90	0 8	19 0
B208389	2085584	751687	Bedrock	K(clst)	5876 80	1 9	5878 7	3 4-7 8	5873 4-5869 0	0 2	5876 60	0 2	16 3
B208489	2085636	751683	Bedrock	K(clst)	5876 30	2.0	5878 3	19 8-29 2	5856 5 5847 1	15 5	5860 80	15 5	33 2
B208589	2085477	751804	Colluvial	Qc/K(clst)	5856 50	1 9	5858 4	3 2-4 0	5853 3-5852.2	3 6	5852.90	3 6	9 6
B208689	2085250	751728	Bedrock	K(clst)	5867 60	2.0	5869 6	12.3-21 8	5855 3-5845 8	7 4	5860 20	7 4	28 4

TABLE 3 5-2
HISTORICAL BORING AND MONITORING WELL INFORMATION INCLUDING STRATIGRAPHIC DATA

New Site Number	True State Plane Coordinates (1) Easting (ft)	Northing (ft)	Well Type/ Boring	Stratigraphy of Screened Interval	Ground Surface Elevation (1) (2) (ft AMSL)	Well Casing Stickup (ft AGS)	Top of Well Casing Elevation (ft AMSL)	Screened Interval Depth (ft BGS)	Screened Interval Elevation (ft AMSL)	Top of Bedrock (3) Depth (ft BGS)	Top of Bedrock (3) Elevation (ft AMSL)	Alluvial Thickness (ft)	Boring Total Depth (ft BGS)
B208789	2084450	751755	Bedrock	K(clst)	5907 10	1 9	5909 0	2.9-10 9	5904 2 5896 2	4 5	5902.60	4 5	14 4
P209989	2084649	751565	Colluvial	Qc	5898 10	2.3	5900 4	3 8-8 2	5894 3-5889 9	7 7	5890 40	7 7	12.0
North Walnut Creek Drainage													
P210089	2084639	751564	Bedrock	K(clst/sltst)	5898.40	2.0	5900 4	12.2 21 5	5886.2-5876 9	7 2	5891 20	7 2	28.0
B210389	2085116	751696	Bedrock	K(clst)	5873 20	2.1	5875 3	13 6-23 1	5859 6-5850 1	8 6	5864 60	8 6	28.5
B210489	2085513	751802	Alluvial	Qvf	5856 40	2.3	5858.7	3 0-7 4	5853.4-5849 0	7 0	5849 40	7 0	28 1
40991	2087538	752163	Alluvial	Qvf	5801 19	(4)	(4)	5 9-7 4	5795.3-5793 8	7 4	5793 79	7 4	10 1
41091	2089994	753241	Alluvial	Qvf	5719 56	(4)	(4)	7 8-10.3	5711 8-5709 3	10 0	5709 56	10 0	13 0
South Walnut Creek Drainage													
3486	2086193	750162	Bedrock	K(ss/sltst)	5912.00	1 9	5914.0	44.2-56.2	5867 8-5855 8	15 9	5896 10	15 9	100 0
3586	2086219	750167	Alluvial	Qvf	5910 75	2.0	5912.8	4.9-11 6	5905.9-5899 2	10 5	5900.25	10 5	18.0
3686	2086820	750387	Alluvial	Qvf/K(clst)	5883 69	1 5	5885 2	3 5-6 5	5880.2-5877 2	5 5	5878.19	5 5	10 2
3786	2088854	751561	Alluvial	Qvf/K(clst)	5796.61	1 7	5798.3	3.3-8.6	5793 3-5788.0	7 5	5789 11	7 5	13 0
3886	2090261	752835	Alluvial	Qvf/K(clst)	5734.05	2.0	5736.1	2.9-8.5	5731.2-5725.6	6 0	5728 05	6 0	14 0
B213789	2086677	750538	Colluvial	Qc	5917 80	2.2	5920 0	2.5-6 9	5915 3-5910 9	6 4	5911 40	6.4	9 6
P213889	2086109	750466	Bedrock	K(ss)	5954 10	1 8	5955 9	11.3-20.8	5942.8-5933 3	8.0	5946 10	8 0	31 9
P213989	2086102	750468	Alluvial	Qrf	5954.30	2.1	5956.4	3.3-6 9	5951.0-5947 4	NA	NA	NA	9 7
2491	2086432	749949	Bedrock	K(ss/sltst)	5944 54	(4)	(4)	11.8-16.8	5932.7-5927 7	8.5	5936 0	8 5	24 2
2691	2086043	750385	Bedrock	K(ss/clst)	5934.78	1 6	5936.4	6 0-16 0	5928.8-5918.8	1 1	5933.68	1 1	18.3
Walnut Creek													
486A	2093851	753482	Alluvial	Qvf	5643 86	1 1	5644.9	3 5-14.9	5640 4-5629.0	14 0	5629.86	14.0	18 0
41691	2093851	753470	Alluvial	Qvf	5643 95	2.0	5646 0	5 1 14.7	5638.9-5629 3	14 7	5629 25	14.7	17 4
Unnamed Tributary													
586	2089776	753703	Alluvial	Qvf	5720 07	2.5	5722.6	4.4-9 8	5715 7-5710 3	9 0	5711 07	9 0	14.0
686	2086654	753569	Alluvial	Qvf	5814.68	2.0	5816 7	3.3-8.9	5811.4-5805 8	10.5	5804.18	10.5	14.0
4087	2084823	753143	Alluvial	Qal	5883 00	1 6	5884.6	3 5-6.5	5879.5-5876.5	5 8	5877.20	5 8	13.0
*4187	2084821	753118	No Log	Unknown	5882.95	1 5	5884.5	81.2-93.8	5801 8-5789.2	No Log	Unknown	Unknown	110 0
4287	2085525	753342	Alluvial	Qvf	5854.34	1 5	5855 9	3.0-6.4	5851 3-5847 9	6 1	5848.24	6 1	12.4
B206989	2084835	753145	Bedrock	K(clst)	5882.42	1 9	5884.3	11 8-21.3	5870.6-5861 1	6 0	5876.42	6.0	23 6
B207089	2084837	753103	Bedrock	K(clst)	5883 07	1 9	5885 0	31 3-53.0	5851 8-5830.1	6.0	5877 07	6 0	60 0
B207189A	2084837	753092	Bedrock	K(clst)	5884 80	1 9	5886 7	71.0-75 4	5813 8-5809 4	5 5	5879 30	5 5	259 0
DAMS													
THO46392	2088478	752464	Boring	NA	5799 14	NA	NA	NA	NA	41 0	5758.14	NA	
THO46692	2087133	750582	Boring	NA	5885 22	NA	NA	NA	NA	27 1	5858.12	NA	36 0
THO46792	2087216	750566	Piezometer	NA	5871.38	2.6	5874.0	6.5-14 0	5864 9-5857 4	14.0	5857.38	NA	19 7
THO46892	2087866	750809	Boring	NA	5857 86	NA	NA	NA	NA	21.0	5836.86	NA	26.5
THO46992	2087890	750817	Piezometer	NA	5856 55	2.6	5859 2	10.0-25 0	5846 6-5831 6	25.0	5831 55	NA	31 0
THO47092	2087914	750842	Piezometer	NA	5841 58	2.6	5844.2	6.0-11 0	5835 6-5830 6	11 0	5830.58	NA	16 5

TA 3 5-2

HISTORICAL BORING AND MONITORING WELL INFORMATION INCLUDING STRATIGRAPHIC DATA

New Site Number	True State Plane Coordinates (1) Easting (ft)	Northing (ft)	Well Type/ Boring	Stratigraphy of Screened Interval	Ground Surface Elevation (1) (2) (ft AMSL)	Well Casing Stickup (ft AGS)	Top of Well Casing Elevation (ft AMSL)	Screened Interval Depth (ft BGS)	Elevation (ft AMSL)	Top of Bedrock (3) Depth (ft BGS)	Elevation (ft AMSL)	Alluvial Thickness (ft)	Boring Total Depth (ft BGS)
OU2													
46692	2087077	749554	Bedrock	K(sltst/ss)	5956 20	2.0	5958 2	72 0-87 0	5884 2 5869 2	24 9	5931 30	24 9	90 1
46792	2087080	749538	Bedrock	K(sltst)	5956 30	2 0	5958 3	96 8-111 8	5859 5 5844 5	25 0	5931 30	25 0	118 8
46892	2087087	749524	Bedrock	K(sltst/ss)	5956 70	2.0	5958 7	146 9-161 9	5809 8-5794 8	25 4	5931 30	25 4	165 2
OU4													
40093	2085093	751569	Boring	NA	5897 40	NA	NA	NA	NA	8 4	5889 00	8 4	14 2
40293	2084904	751520	Boring	NA	5901 90	NA	NA	NA	NA	NE	NE	Unknown	6 2
40393	2085447	751256	Boring	NA	5932.10	NA	NA	NA	NA	6 0	5926 10	6 0	12.0
40493	2085711	751541	Boring	NA	5883 60	NA	NA	NA	NA	4 7	5878 90	4 7	8 0
40593	2085558	751491	Boring	NA	5909 50	NA	NA	NA	NA	21 0	5888 50	21 0	26 0
40693	2084477	751206	Boring	NA	5939 40	NA	NA	NA	NA	1 0	5938 40	1 0	6 0
40793	2084627	751089	Boring	NA	5956 00	NA	NA	NA	NA	8 5	5947 50	8 5	13 0
40893	2085100	751078	Boring	NA	5956 30	NA	NA	NA	NA	6 3	5950 00	6 3	11 2
40993	2084436	750962	Boring	NA	5981 30	NA	NA	NA	NA	9 7	5971 60	9 7	34 5
41293	2085182	751047	Boring	NA	5954 70	NA	NA	NA	NA	3 3	5951 40	3 3	9 0
41593	2084771	750922	Boring	NA	5969 40	NA	NA	NA	NA	5 9	5963 50	5 9	7 9
41793	2085228	750897	Boring	NA	5963 80	NA	NA	NA	NA	12.3	5951 50	12.3	18 0
42093	2084543	750982	Boring	NA	5976 70	NA	NA	NA	NA	4 8	5971 90	4 8	10 0
42193	2084701	750876	Boring	NA	5971 00	NA	NA	NA	NA	7 4	5963 60	7 4	31 3
42293	2085093	750797	Boring	NA	5973 40	NA	NA	NA	NA	NE	NE	Unknown	12.8
42493	2084681	750762	Boring	NA	5971 70	NA	NA	NA	NA	8 1	5963 60	8 1	10 2
42593	2084826	750748	Boring	NA	5969 80	NA	NA	NA	NA	8 0	5961 80	8 0	16 8
42693	2084649	751154	Boring	NA	5944 90	NA	NA	NA	NA	1 0	5943 90	1 0	6 0
42893	2084452	750612	Boring	NA	5978 10	NA	NA	NA	NA	7 2	5970 90	7 2	12.0
43193	2085229	750704	Boring	NA	5964 40	NA	NA	NA	NA	10 5	5953 90	10 5	16 0
43393	2084680	750563	Boring	NA	5972.50	NA	NA	NA	NA	5 0	5967 50	5 0	13 6
43493	2085097	750602	Boring	NA	5973 50	NA	NA	NA	NA	NE	NE	Unknown	11 3
43693	2084727	750521	Boring	NA	5972.40	NA	NA	NA	NA	10 0	5962.40	10 0	13 0
43793	2084908	750688	Boring	NA	5972.10	NA	NA	NA	NA	11 3	5960 80	11 3	17 0
44093	2085223	750463	Boring	NA	5968 40	NA	NA	NA	NA	11 4	5957 00	11 4	16 3
44193	2085601	750435	Boring	NA	5960 60	NA	NA	NA	NA	12.1	5948 50	12.1	50 4
44393	2084665	750286	Boring	NA	5976 90	NA	NA	NA	NA	7 5	5969 40	7 5	13 0
44593	2085199	750305	Boring	NA	5970 10	NA	NA	NA	NA	11 4	5958 70	11 4	14 2
44693	2085999	751480	Boring	NA	5895 00	NA	NA	NA	NA	0 0	5895 00	0 0	14 0
44793	2086072	751198	Boring	NA	5913 10	NA	NA	NA	NA	2.5	5910 60	2.5	12.0
46593	2085002	750857	Boring	NA	5964 10	NA	NA	NA	NA	7 8	5956 30	7 8	16 4
46693	2085073	750953	Boring	NA	5963 20	NA	NA	NA	NA	6 9	5956 30	6 9	14 8
46793	2035113	750888	Boring	NA	5963 50	NA	NA	NA	NA	6 5	5957 00	6 5	14 7

TABLE 3 5-2

HISTORICAL BORING AND MONITORING WELL INFORMATION INCLUDING STRATIGRAPHIC DATA

New Site Number	True State Plane Coordinates (1) Easting (ft)	Northing (ft)	Well Type/ Boring	Stratigraphy of Screened Interval	Ground Surface Elevation (1) (2) (ft AMSL)	Well Casing Stickup (ft AGS)	Top of Well Casing Elevation (ft AMSL)	Screened Interval Depth (ft BGS)	Screened Interval Elevation (ft AMSL)	Top of Bedrock (3) Depth (ft BGS)	Top of Bedrock (3) Elevation (ft AMSL)	Alluvial Thickness (ft)	Boring Total Depth (ft BGS)
47093	2085047	750656	Boring	NA	5964 70	NA	NA	NA	NA	NE	NE	Unknown	9 8
OU-7													
70093	2082657	752675	Alluvial	Qrf	5990 90	(4)	(4)	7 0-22.0	5984 0-5969 0	22.2	5968 70	22.2	24 4
70193	2082674	752688	Bedrock	K(slst, ss)	5990 00	(4)	(4)	22.3 37 3	5967 7 5952.7	19 5	5970 50	19 5	39 4
70293	2082665	752681	Bedrock	Ks	5993 10	(4)	(4)	52.1-67 1	5941 0-5926 0	30 0	5963 10	30 0	73 3
70393	2082389	752090	Alluvial	Qrf	5997 90	(4)	(4)	7 8-22.8	5990 1 5975 1	22.8	5975 10	22.8	26 0
South of PA													
P313489	2083062	748913	Alluvial	af/Qrf	6011 70	(4)	(4)	16.7 21 1	5995 0-5991 5	20 6	5991 10	20 6	24.0
P317989	2084272	748891	Alluvial	af/Qrf	5990 90	(4)	(4)	3-7 3	5987.9-5983 4	6 4	5984 50	6.4	16 0
P320089	2083280	748799	Alluvial	af/Qrf	6009.90	(4)	(4)	14 4-18.8	5991.1-5995 5	18.8	5991 10	18.8	20 9
42792	2085337	748674	Boring	NA	5982.30	NA	NA	NA	NA	20 4	5961 90	20 4	44.3
42892	2085012	748876	Boring	NA	5984 10	NA	NA	NA	NA	7 0	5977 10	7 0	159 6
42992	2083962	749231	Boring	NA	5995 20	NA	NA	NA	NA	6 5	5988.70	6.5	40 2
43192	2083061	748995	Boring	NA	6010 30	NA	NA	NA	NA	17 2	5993 10	17 2	60 1

EXPLANATION

Qal- Quaternary Alluvium (undifferentiated)
Qvf- Quaternary Valley-Fill Alluvium
Qrf- Quaternary Rocky Flats Alluvium
Qc- Quaternary colluvium
K(ss)- Cretaceous sandstone
K(clst)- Cretaceous claystone
K(slst)- Cretaceous siltstone

af artificial fill (man-made deposits)
AGS- Above Ground Surface
BGS- Below Ground Surface
AMSL- Above Mean Sea Level
* No borehole log available
NA- not applicable
A abandoned wells

NOTES

1 Ground surface elevation and true state plane coordinates are resurveyed data for 1986 and 1987 wells as of 12/06/91
2. Ground surface elevations for monitoring wells installed from 1986 to 1992 are measured at the top of the concrete pad.
Typical thickness of a concrete pad is 6 inches.
All elevations for the 1993 monitoring wells are measured from the ground surface.
3 Monitoring wells were reamed across the alluvial/bedrock contact. The depth and elevation of the Top of Bedrock is taken from the paired site.
4. Monitoring well installation form not available.
5 Information from OU2 stratigraphic table (DOE 1993e).

TABLE 3 5-3
OU6 PHASE I GRAIN SIZE DATA
FOR SELECTED SOIL SAMPLES

			Grain Size Percentage								
			Percentage retained on sieve								
		Sample	Gravel				Sand			Fines	USCS
Site	IHSS	Depth	1 5"	3/4"	3/8"	#4	#10	#40	#200	Pan	Soil
Number	Number	(ft BGS)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	Classification
60292	143	0 0-2 0'	0	3 1	12 9	4 8	12 6	9 5	23 8	33 3	SC
73992	156 2	0 0-2 0'	0	73 3	13 9	1 5	1 9	5 8	2 3	1 2	SC
74192	156 2	0 0-2 0'	0	0	7 7	3 6	8 1	38	32 1	10 5	GC
72292	165	0 0-2 0'	0	27 3	27 3	11 5	7 1	11 7	11 6	3 5	SC
66892	166 1	0 0 2 0	73 5	10 6	0	4 5	1 6	5 3	3 7	0 8	GC
67692	166 2	0 0 2 0'	0	3 9	5 5	13 8	13 2	36 3	23 3	4	SC
68692	166 3	0 0 2 0'	17 1	21	29 1	14 7	5 4	4 2	7 2	1 3	SC
62192	167 1	0 0-2 0'	0	62 7	19 8	3 9	3 3	5 2	2 9	1 9	GW
62992	167 1	0 0 2 0'	0	53	28 4	7	2 8	5	2 8	1 4	GC
66292	167 3	0 0-2 0'	40 3	0	32 2	8	4	4	7 6	4	GC
66592	167 3	0 0-2 0'	0	27 2	36 7	7 2	7 2	10	10 8	0 9	GM

BGS - below ground surface
IHSS Individual Hazardous Substance Site
USCS Unified Soil Classification System

GW - Well graded Gravel
GM - Silty Gravel
GC - Clayey Gravel
SC - Clayey Sand

TABLE 3.5-4
OU6 POND SEDIMENT SOIL CLASSIFICATION

Sediment Site	IHSS	State Plane Coordinates		Unified Soil Classification System Pond Sediment Classification							
Number	Location	Easting	Northing	Soil Group*	Interval (in.)	Soil Group*	Interval (in.)	Soil Group*	Interval (in.)	Soil Group*	Interval (in.)
60092	142 1	2086553	752020	OL	0 0 9 5	CL	9 5 18 0				
60192	142 1	2086270	751966	CL	0 0-7 5	OL	7 5 16 25				
60292	142 1	2086426	751947	OL	0 0-9 8	CL	9 8 19 3				
60392	142 1	2086505	752010	OL	0 0-3 3	CL	3 3-20 0				
60492	142 1	2086292	751931	OL	0 0-5 5	CL	5 5-13 5				
60592	142 2	2086993	752094	CL	0 0-7 5						
60692	142 2	2087179	752087	CL	0 0-8 5						
60792	142 2	2087253	752165	OL	0 0-3 5	CL	3 5-6 0				
60892	142 2	2087310	752174	OL	0 0-2 5	CL	2 5-6 0				
60992	142 2	2086964	752116	CL	0 0-8 0						
61092	142 3	2088256	752395	CL	0 0-14 2	OL	14 2 22 7				
61192	142 3	2088168	752356	OL	0 0-4 1	CL	4 1 14 4				
61292	142 3	2087986	752260	CL	0 0-10.2	CL	10 2-12 4				
61392	142 3	2088323	752536	SC	0 0-4 9	OL	4 9-14 1				
61492	142 3	2087818	752311	CL	0 0-12 0						
61592	142 4	2089497	752865	CL	0 0-6 3						
61692**	142 4	2089723	752971	CL	0 0-1.2	SS	1.2 1 8	CLYST	1 8-2 8		
61792**	142 4	2089448	752924	CL	0 0-3 0	SLTY CLYST	3 0-6 6				
61892	142 4	2089674	753022	CL	0 0-2 8						
61992	142 4	2089294	752953	CL	0 0-2 5	SC	2 5-3 5	CL	3 5-9 4		
62092	142 5	2087052	750536	OL	0 0-6 0	CL	6 0-13 0	OL	13 0-25 0	CL	25 0-29 0
62192	142 5	2087119	750520	OL	0 0-2 0	CL	2 0-11 0				
62292	142 5	2087102	750523	OL	0 0-6 0	CL	6 0-11 0	OL	11 0-24 0		
62392	142 5	2087083	750556	OL	0 0-17 0	CL	17 0-18 0				
62492	142 5	2086983	750455	OL	0 0-7 0	CL	7 0-18 0				
62592	142 6	2087378	750642	OL	0 0-6 0	CL	6 0-20 0				
62692	142 6	2087281	750604	CL	0 0-8 0						
62792	142 6	2087495	750623	OL	0 0-6 0						
62892	142 6	2087456	750609	OL	0 0-2 0	CL	2 0-14 0				
62992	142 6	2087217	750618	OL	0 0-9 0	CL	9 0-15 0				
63092	142 7	2087848	750765	SM/SP	0 0-3 8	OL	3 8-7 9	CL	7 9-12 5		
63192	142 7	2087815	750837	OL	0 0-3.2	CL	3 2 16 0				
63292	142 7	2087796	750757	OL	0 0-12 6	CL	12.6-20 4				
63392	142 7	2087793	750792	OL	0 0-9 2	CL	9.2-25 5				
63492	142 7	2087698	750786	CL	0 0-6 4						
63592	142 8	2088169	750869	CL	0 0-6.2	SM	6.2 18 3	CL	18 3-28 3		
63692	142 8	2088194	750929	SM/SP	0 0-4 9	CL	4 9-15 9				
63792	142 8	2088256	750872	CL	0 0-31 5						
63892	142 8	2088233	750898	CL	0 0-25 4	OL	25 4-30 9				

TABLE 3.5-4
OU6 POND SEDIMENT SOIL CLASSIFICATION

Sediment Site	IHSS	State Plane Coordinates		Unified Soil Classification System Pond Sediment Classification							
Number	Location	Easting	Northing	Soil Group*	Interval (in.)	Soil Group*	Interval (in.)	Soil Group*	Interval (in.)	Soil Group*	Interval (in.)
63992	142 8	2088119	750912	SM	0 0-10 2	ML	10 2 12 9				
64092	142 9	2089080	751734	OL	0 0 7 0	SP	7 0-8 5				
64192	142 9	2089540	751924	OL	0 0 1 0	CL	1 0 5 6				
64292	142 9	2089466	752081	CL	0 0 2 9	OL	2 9 8 4				
64392	142 9	2089521	751994	OL	0 0-6 9	SM/SW	6 9 8 8				
64492	142 9	2088990	751706	SM	0 0 1 2	OL	1 2 2 5				
64592	142 12	2093510	753694	OL	0 0 5 0	SM	5 0 11 5				
64692	142 12	2093554	753636	OL	0 0-9 5	CL	9 5 22 0				
64792	142 12	2093513	753756	CL	0 0-2 0	OL	2 0-5 0				
64892	142 12	2093563	753684	CL	0 0 11 0						
64992	142 12	2093452	753746	CL	0 0-4 0	OL	4 0-6 0	SM	6 0-7 0		

Explanation
- * USCS Soil Group estimated in the field by visual criteria
- ** Bedrock
- CLYST Claystone
- SLTY CLYST Silty Claystone
- SS Sandstone
- ML Silt
- OL Organic Clays
- CL- Clay
- SM Silty Sand (fines > 12%)
- SM/SP Silty Sand (12% >fines<5%)
- SP Poorly sorted Sand (fines<5%)
- SC Clayey Sand

TABLE 3 5-5
BOREHOLES AND MONITORING WELLS THAT PENETRATED QUATERNARY ROCKY FLATS ALLUVIUM

BOREHOLES			MONITORING WELLS		
* 60092	* 67792	* 77692	* 2386	B206289	* P219589
* 60192	* 67892	* 77792	* 2486	B206389A	* P313489
* 60292	* 67992	* 77892	* 2786	• B206489	* P317989
* 60392	* 68092	* 77992	* 2886A	B206589	* P320089
* 60492	* 68192	78192	* 2986	P207389	2491
* 60692	* 68292	78292	3486	* P207489	* 2691
61192	• 68392	78392	* 2187	* P207689A	* 42792
61292	* 68492	78492	* 2287	* P207789	* 42892
61392	* 68592	78592	* 3887	P207889	• 42992
61492	* 68692	* 40093	* 3987	• P207989	* 43192
61692	* 68792	* 40293	6087	* P208989	* 46692
61792	* 68892	• 40393	6187	* P209489	* 46792
61892	* 68992	* 40493	6287	• P209589	* 46892
62192	* 69092	• 40593	6387A	* P209689	• 75892
62292	• 69192	• 40693	6487	* P209789	* 76192
62392	• 69292	* 40793	6587	* P210289A	* 76292
62492	* 69392	* 40893	6687	P213889	* 76792
62592	* 72292	* 40993	6787A	P213989	76992
62692	* 72392	* 41293	6887	* P218089	77392
62792	* 72492	* 41593	7087	* P218389	• 77492
62892	* 72592	* 41793	7187	* P219089	* 5193
62992	* 72692	• 42093	7287	• P219189	• 5393
63092	• 72792	42193	* B206189A	* P219489	
63192	* 72892	42293			
63292	* 72992	42493			
63392	* 73092	42593			
* 63592	* 73292	42893			
* 63692	* 73392	43193			
66092	* 73492	• 43393			
66192	* 73592	* 43493			
66292	* 73692	43693			
66392	* 73792	43793			
66492	* 73892	44093			
66592	* 73992	44193			
66692	* 74092	44393			
* 66792	* 74192	44593			
* 66892	* 74292	44793			
* 66992	* 74392	46593			
* 67092	• 74492	46693			
* 67192	* 74592	46793			
* 67292	* 74692	* 47093			
• 67392	* 74792	* 70093			
* 67492	* 74892	* 70193			
* 67592	* 74992	* 70293			
* 67692	* 77592	* 70393			

A - Abandoned well

* - Upper portion of section consists of man-made deposits

TABLE 3 5-6
BOREHOLES AND MONITORING WELLS THAT PENETRATED QUATERNARY HIGH TERRACE ALLUVIUM

BOREHOLES	MONITORING WELLS
None	1886

TABLE 3 5-7
BOREHOLES AND MONITORING WELLS THAT PENETRATED QUATERNARY VALLEY-FILL ALLUVIUM

BOREHOLES	MONITORING WELLS		
None	486A	3586	B208789
	586	3686	B210389
	686	3786	B210489
	786	3886	P209989
	1186A	* 2287	P210089
	1286A	4087	40991
	1386	4287	41091
	1486	B206989	41691
	1586	B207089	* 75092
	1786	B207189A	75292
	3486	B208089A	77192

A Abandoned well
* - Upper portion of section may be disturbed by man-made activity

TABLE 3 5-8
BOREHOLES AND MONITORING WELLS THAT PENETRATED QUATERNARY COLLUVIUM

BOREHOLES	MONITORING WELLS		
61992	1586	B207289	B208689
64992	1786	B208089	B210389
65492	3786	* B208189	B210489
65992	* 2187	B208289	B213789
	* 2287	B208389	75992
	B206689	B208489	76792
	B206889	B208589	77192

* - Upper portion of section may be disturbed by man-made activity

TABLE 3 5-9
BOREHOLES AND MONITORING WELLS THAT PENETRATED QUATERNARY MAN-MADE DEPOSITS

BOREHOLES			MONITORING WELLS		
# 60092	# 69192	40093	1986	P207389	P219489
# 60192	# 69292	40293	2386	P207489A	P219589
# 60292	# 69392	40393	2486	P207689	P313489
# 60392	# 72292	40493	2786	P207789	P317989
# 60492	# 72392	40593	2886A	P207889	P320089
# 60692	# 72492	40693	2986	P207989	2691
# 63592	# 72592	40793	3086	P208889	42792
# 63692	# 72692	40893	3186	P208989	42892
64792	# 72792	40993	3286	P209489	42992
64892	# 72892	41293	2187	P209589	43192
65092	# 72992	41593	2287	P209689	# 75892
65192	# 73092	41793	3887	P209789	# 76192
65292	# 73292	42093	3987	P209889	76292
65392	# 73392	42193	B206189A	P210289A	77492
65692	# 73492	42293	B206389A	P218089	THO46792
65892	# 73592	42493	B206489	P218389	THO46992
# 66892	# 73692	42593	B206789	P219089	THO47092
# 66992	# 73792	42693	B208189	P219189	5193
# 67092	# 73892	42893			5393
# 67192	# 73992	43193			
# 67292	# 74092	43393			
# 67392	# 74192	43493			
# 67592	# 74292	43693			
# 67692	# 74392	43793			
# 67792	# 74492	44093			
# 67892	# 74592	44193			
# 67992	# 74692	44393			
# 68092	# 74792	44593			
# 68192	# 74892	44793			
# 68292	# 74992	46593			
# 68392	# 77592	46693			
# 68492	# 77692	46793			
# 68592	# 77792	47093			
# 68692	# 77892	70093			
# 68792	# 77992	70193			
# 68892	THO46392	70293			
# 68992	THO46692	70393			
# 69092	THO46892				

A - Abandoned well
- Man-made deposits included reworked Rocky Flats Alluvium (RFA)

TABLE 3 5-10
BOREHOLES AND MONITORING WELLS THAT PENETRATED UPPER CRETACEOUS CLAYSTONE AND/OR SILTSTONE

BOREHOLES			MONITORING WELLS		
* 60692	* 68692	* THO46692	486A	7187	P210089
61992	* 68792	* 40093	586	7287	* P210289A
62092	* 68892	* 40393	686	* B206189A	P213989
62792	* 68992	* 40493	786	B206289	* P218089
* 63592	* 69092	* 40593	886	* B206389A	* P218389
* 63692	* 69192	* 40693	1186A	* B206489	* P219089
* 64792	* 69292	* 40793	1286A	B206589	* P219189
* 64892	* 69392	* 40893	1386	B206689	* P219489
64992	* 72292	* 40993	1486	• B206789	* P219589
* 65292	* 72392	* 41293	1586	B206889	* P313489
* 65392	* 72792	* 41593	1686	B207089	* P317989
* 65592	* 72992	* 41793	1786	B207189A	* P320089
* 65692	• 73092	* 42093	1886	B207289	* 02491
* 65792	* 73592	* 42193	* 1986	B208089	* 2691
* 65892	* 73692	* 42493	* 2386	* B208189	40991
* 66892	* 73892	* 42593	* 2486	B208289	41091
* 66992	* 73992	* 42693	* 2786	B208389	41691
67092	* 74092	* 42893	* 2886A	B208489	* 42792
67192	* 74192	* 43393	* 2986	B208589	* 42892
* 67292	* 74292	* 43693	* 3086	B208689	44492
* 67392	* 74392	* 43793	* 3186	B208789	46392
67492	* 74492	* 44093	* 3286	B210389	46692
* 67592	* 74592	* 44193	3486	B210489	46792
* 67692	* 74692	* 44393	3586	B213789	46892
* 67792	* 74792	* 44593	3686	B217689	* 75092
* 67892	* 74992	* 44693	3786	P207389	75292
* 67992	* 77592	* 46593	* 3886	P207489A	* 75892
* 68092	* 77692	* 46693	* 2287	* P207689	75992
* 68292	* 77792	* 46793	* 3987	* P207789	* 76192
* 68392	* 77892	* 70093	4087	P207889	76792
* 68492	78092	* 70193	4187	* P207989	76992
* 68592	* THO46392	* 70293	4287	* P208889	77392
		* 70393	6387A	* P208989	* 77492
			6487	* P209489	B206992
			6587	* P209589	THO46792
			6687	* P209689	THO46992
			6787A	* P209789	THO47092
			6887	• P209889	* 5193
			7087	P209989	* 5393

A - Abandoned well

* - Upper portion of section consists of man-made deposits

TABLE 3 5-11
BOREHOLES AND MONITORING WELLS THAT PENETRATED THE UPPER CRETACEOUS ARAPAHOE NO 1 SANDSTONE

BOREHOLES		MONITORING WELLS		
* 67692	* 40493	* 3186	* P207389	* P218389
* 72292	* 40993	* 3286	* P208889	* P219589
* 72892	* 42193	3486	* P208989	2491
* 73392	* 70193	* 2287	* P209489	* 2691
* 73492	* 70293	6487	P213889	• 42792
* 73792		6687	P213989	* 42992
* 77792		* B217689	* P218089	46792
* THO46892				* 76292

* - Upper portion of section consists of man-made deposits

TABLE 3 6-1
OU6 AND OTHER OU INVESTIGATIONS
APRIL 1993 HYDROGEOLOGIC DATA

Site Number	True State Plane Coordinates Easting	True State Plane Coordinates Northing	Stratigraphy of Screened Interval	Hydrostratigraphic Unit (HSU)	Justification for HSU Designation	Top of Screen Elevation (ft AMSL)	Bottom of Screen Elevation (ft AMSL)	Groundwater Elevation (ft AMSL)	Top of Bedrock Elevation (ft AMSL)	Saturated Alluvial Thickness(1) (ft)	Depth to Water (ft-BTOC)	Water Level Measurement Date
1186	2090010	753331	Qvf	UHSU	*	5714 1	5707 7	5714 8	5708 5	6 3	5 25	1 Apr-93
1386	2086051	751857	Qvf	UHSU	*	5834 1	5827 7	5834 9	5828 2	6 6	4 87	2 Apr-93
1486	2085838	751856	K(ss)	LHSU	** ***	5808 1	5792 1	5839 2	5836 5	2 6	10 21	2 Apr-93
1586	2085812	751852	Qvf	UHSU	*	5844 3	5833 7	5844 4	5835 9	8 5	6 22	2 Apr-93
1686	2085260	751747	K(sltst/clst/ss)	LHSU	***	5828 8	5822 8	5863 9	5860 9	2 9	5 68	2 Apr 93
1786	2085242	751740	Qvf/K(clst)	UHSU	*	5864 7	5854 4	5863 7	5855 9	7 7	5 92	2-Apr-93
1886	2085831	751522	Qvf	UHSU	*	5882 1	5878 3	5878 8	5877 8	1 1	9 16	5-Apr-93
1986	2083296	750894	Qvf	UHSU	*	5940 1	5930 8	5941 9	5929 4	12 6	1 92	1 Apr-93
2187	2085799	749969	Qvf/K(clst)	UHSU	**	5925 1	5918 0	5921 1	5920 4	0 7	8 56	1-Apr-93
2287	2085821	749924	K(ss sltst)	LHSU	**	5849 8	5842 7	5852 4	5918 4	-66 0	80 38	1 Apr-93
2786	2085238	750781	K(sltst/clst)	LHSU	**	5834 4	5829 9	5884 6	5951 9	-67 3	79 32	20-Apr-93
2986	2085687	750599	Qc	UHSU	*	5956 8	5950 8	5950 3	5951 1	-0 8	10 42	1 Apr-93
3086	2084921	751078	K(clst)	UHSU	**	5954 9	5942 5	5953 7	5954 9	1 2	4 68	20-Apr-93
3286	2084743	751050	K(ss)	LHSU	**	5851 2	5840 6	5913 9	5965 1	-51 2	54 03	22-Apr-93
3486	2086193	750162	K(ss clst,sltst)	LHSU	**	5867 8	5855 8	5892 8	5896 1	3 3	21 13	7-Apr-93
3586	2086219	750167	Qvf	UHSU	*	5905 9	5899 2	5906 1	5900 3	5 9	6 65	7-Apr-93
3686	2086820	750387	Qvf	UHSU	*	5880 2	5877 2	5879 1	5878 2	0 9	6 15	1-Apr-93
3786	2088854	751561	Qvf	UHSU	*	5793 3	5788 0	5795 5	5789 1	6 4	2 8	8-Apr-93
3886	2090261	752835	Qvf	UHSU	*	5731 2	5725 6	5730 6	5728 1	2 6	5 44	1-Apr-93
3887	2085094	750396	Qrf	UHSU	*	5968 7	5962 9	5963 5	NA	NA	10 38	1-Apr-93
3987	2085268	751081	K(sltst)	LHSU	**	5837 0	5829 9	5854 4	5943 5	89 0	93 99	1-Apr-93
4087	2084823	753143	Qal	UHSU	*	5879 5	5876 5	5881 2	5877 2	4 0	3 39	1 Apr-93
4187(2)	2084821	753118	K	LHSU	**	5801 8	5789 2	5822 6	NA	NA	61 93	1-Apr-93
4287	2085525	753342	Qvf	UHSU	*	5851 3	5847 9	5852 6	5848 2	4 4	3 23	1-Apr-93
6087(2)	2083035	752930	Qrf	UHSU	*	5980 9	5956 9	5975 6	NA	NA	10 37	1-Apr-93
6187(2)	2083072	752860	Qrf	UHSU	*	5980 9	5956 2	5974 9	NA	NA	10 91	2-Apr-93
6287(2)	2083097	752800	Qrf	UHSU	*	5981 0	5957 9	5973 6	NA	NA	12 8	2-Apr 93
6487	2083261	752329	Qrf	UHSU	*	5973 1	5962 8	5966 3	5964 1	2 2	21 05	2-Apr-93

TABLE 3 6-1
OU6 AND OTHER OU INVESTIGATIONS
APRIL 1993 HYDROGEOLOGIC DATA

Site Number	True State Plane Coordinates		Stratigraphy of Screened Interval	Hydrostratigraphic Unit (HSU)	Justification for HSU Designation	Top of Screen Elevation (ft AMSL)	Bottom of Screen Elevation (ft AMSL)	Groundwater Elevation (ft AMSL)	Top of Bedrock Elevation (ft AMSL)	Saturated Alluvial Thickness(1) (ft)	Depth to Water (ft-BTOC)	Water Level Measurement Date
	Easting	Northing										
6587	2083299	752230	Qrf	UHSU	*	5972 8	5959 5	5971 3	5962 5	8 9	13 65	2-Apr-93
6687	2083325	752150	Qrf	UHSU	*	5978 9	5964 3	5971 3	5967 0	4 3	12 42	1-Apr-93
6787	2083774	753164	Qrf	UHSU	*	5958 3	5953 5	5962 1	5953 6	8 5	9 65	2-Apr-93
6887	2083776	753145	Qrf	UHSU	*	5957 7	5953 1	5961 8	5953 3	8 5	8 51	2-Apr-93
7087	2084196	752571	Qrf	UHSU	*	5963 2	5950 4	5950 6	5954 7	-4 1	17 79	2-Apr-93
7187	2084087	753322	Qrf	UHSU	*	5960 4	5950 4	5960 1	5949 9	10 2	5 43	1-Apr-93
7287	2083953	752441	Qrf	UHSU	*	5966 1	5962 8	5966 8	5961 6	5 2	4 46	1-Apr-93
41691	2093851	753470	Qvf	UHSU	*	5638 9	5629 3	5638 9	5629 3	9 7	7 02	6-Apr-93
75092	2089870	753228	K(clst)	UHSU	**	5716 2	5708 7	5710 0	5717 1	-7 1	15 28	1-Apr-93
75292	2089809	752305	Qvf	UHSU	*	5749 3	5747 3	5751 7	5747 3	4 4	5 23	1-Apr-93
75892	2086558	750915	Qrf	UHSU	*	5951 9	5948 9	dry	5948 6	dry	dry	1 Apr-93
75992	2086628	750290	Qc	UHSU	*	5892 1	5887 1	5892 8	5887 1	5 7	6 29	1-Apr-93
76192	2086122	750660	Qrf	UHSU	*	5956 0	5954 0	5953 5	5954 0	-0 5	9 52	7 Apr-93
76292	2085681	750769	K(ss)	UHSU	***	5947 8	5937 8	5942 4	5948 5	-6 1	16 88	1-Apr-93
76792	2084618	752546	Qrf	UHSU	*	5940 0	5937 7	dry	5937 2	dry	dry	1-Apr-93
76992	2084500	752561	Qrf	UHSU	*	5951 6	5945 6	dry	5945 4	dry	dry	1-Apr-93
77192	2084381	753646	Qc	UHSU	*	5911 0	5908 0	5908 5	NE	NA	8 56	8-Apr-93
77392	2084299	752243	Qrf	UHSU	*	5958 6	5955 6	5954 2	5955 5	-1 3	10 29	1-Apr-93
77492	2083508	751246	Qrf	UHSU	*	5929 9	5919 9	5931 3	5919 5	11 8	13 23	1-Apr-93
B206189	2083301	752332	K(clst)	UHSU	***	5958 6	5949 1	5965 5	5963 5	2 0	21 06	2-Apr-93
B206289	2083564	752253	K(clst)	LHSU	**	5945 2	5935 8	5955 3	5962 6	-7 3	24 22	1-Apr-93
B206389	2083926	752548	Qrf	UHSU	*	5965 7	5956 2	5959 9	5956 4	3 5	11 69	2-Apr-93
B206489	2083964	752427	Qrf/K(clst)	UHSU	*	5965 8	5959 1	5966 7	5961 8	4 9	4 8	1-Apr-93
B206589	2084121	752458	K(clst)	UHSU	***	5944 3	5932 6	5960 8	5960 3	0 5	8 86	1-Apr-93
B206689	2084361	752588	K(clst)	UHSU	***	5950 6	5941 1	5941 8	5955 6	-13 8	19 36	1-Apr-93
B206789	2084161	752818	K(clst)	LHSU	**	5918 1	5908 6	5917 7	5923 1	-5 5	12 55	2-Apr-93
B206889	2084781	752823	K(clst)	UHSU	**	5909 1	5899 6	5900 4	5914 1	-13 7	18 84	1-Apr-93
B206989	2084835	753145	K(clst)	LHSU	**	5870 6	5861 1	5861 0	5876 4	-15 4	23 3	1-Apr-93

TABLE 3 6-1
OU6 AND OTHER OU INVESTIGATIONS
APRIL 1993 HYDROGEOLOGIC DATA

Site Number	True State Plane Coordinates Easting	Northing	Stratigraphy of Screened Interval	Hydrostratigraphic Unit (HSU)	Justification for HSU Designation	Top of Screen Elevation (ft AMSL)	Bottom of Screen Elevation (ft AMSL)	Groundwater Elevation (ft AMSL)	Top of Bedrock Elevation (ft AMSL)	Saturated Alluvial Thickness(1) (ft)	Depth to Water (ft-BTOC)	Water Level Measurement Date
B207089	2084837	753103	K(clst)	LHSU	** ***	5851 8	5830 1	5859 2	5877 1	-17 9	25 8	1-Apr-93
B207289	2084360	753267	K(clst)	LHSU	**	5943 1	5933 6	dry	5948 1	dry	dry	1-Apr-93
B208089	2085876	751143	Qvf	UHSU	*	5932 0	5922 5	5923 2	5923 2	0 0	13 9	5-Apr-93
B208189	2085885	751138	K(clst)	LHSU	**	5918 5	5909 1	5913 4	5924 4	-11 0	24 12	5-Apr-93
B208289	2086289	751739	K(clst)	UHSU	**	5844 8	5835 3	5835 4	5849 9	-14 5	17 6	5-Apr-93
B208389	2085584	751687	K(clst)	UHSU	**	5873 4	5869 0	5868 7	5876 6	7 9	9 99	5-Apr-93
B208489	2085636	751683	K(clst)	LHSU	**	5856 5	5847 1	5846 1	5860 8	-14 7	32 23	5-Apr-93
B208589	2085477	751804	Qc/K(clst)	UHSU	*	5853 3	5852 5	5854 7	5852 9	1 8	3 71	2-Apr-93
B208689	2085250	751728	K(clst)	LHSU	**	5855 3	5845 8	5851 7	5860 2	8 5	17 92	2-Apr-93
B208789	2084450	751755	K(clst)	UHSU	**	5904 2	5896 2	5895 7	5902 6	-6 9	13 27	5-Apr-93
B210389	2085116	751696	K(clst)	LHSU	***	5859 6	5850 1	5851 1	5864 6	13 5	24 24	2 Apr-93
B210489	2085513	751802	Qvf	UHSU	*	5853 4	5849 0	5854 9	5849 4	5 5	3 84	2-Apr-93
P207689	2085318	750398	Qrf	UHSU	*	5962 7	5953 2	5959 6	5953 7	5 8	8 33	12-Apr-93
P207789	2085343	750392	K(clst)	LHSU	**	5948 0	5938 5	5938 1	5953 0	14 8	29 67	12-Apr-93
P207889	2085343	750392	af/Qrf	UHSU	*	5959 6	5955 1	5960 9	NA	NA	3 97	7-Apr-93
P207989	2085343	750392	K(clst)	LHSU	**	5952 1	5942 6	5945 0	5957 3	12 3	20 2	7 Apr-93
P208889	2085249	751086	K(clst)	LHSU	**	5859 5	5850 4	5857 2	5941 8	84 7	92 15	1 Apr-93
P208989	2085249	751086	K(ss clst)	UHSU	**	5947 1	5937 7	5947 3	5959 0	-11 8	17 31	1-Apr-93
P209489	2085249	751086	K(ss)	UHSU	**	5962 5	5943 0	5951 4	5969 0	-17 6	28 71	1-Apr-93
P209589	2085286	751071	K(clst)	LHSU	**	5939 1	5929 7	5930 2	5944 1	13 9	19 85	1-Apr-93
P209689	2085514	750533	K(clst)	LHSU	**	5945 4	5935 9	5935 5	5950 4	14 9	28 86	1-Apr-93
P209789	2085481	750579	Qrf	UHSU	*	5959 8	5950 3	5959 3	5950 8	8 5	5 62	5-Apr-93
P209889	2084984	751194	K(clst)	UHSU	**	5931 4	5922 0	5937 3	5936 4	0 9	5 14	1-Apr-93
P209989	2084649	751565	Qc	UHSU	*	5894 3	5889 9	dry	5890 4	dry	dry	5-Apr-93
P210089	2084639	751564	K(clst,sltst)	LHSU	***	5886 2	5876 9	5880 3	5891 2	-10 9	20 11	5-Apr-93
P213889	2086109	750466	K(ss)	LHSU	**	5942 8	5933 3	dry	5946 1	dry	dry	7 Apr-93
P213989	2086102	750468	af/Qrf	UHSU	*	5951 0	5947 4	dry	NA	dry	dry	7-Apr-93
P218389	2085648	750831	Qrf	UHSU	*	5948 1	5943 7	5945 9	5944 2	1 7	12 58	1-Apr-93

TABLE 3 6-1
OU6 AND OTHER OU INVESTIGATIONS
APRIL 1993 HYDROGEOLOGIC DATA

Site Number	True State Plane Coordinates		Stratigraphy of Screened Interval	Hydrostratigraphic Unit (HSU)	Justification for HSU Designation	Top of Screen Elevation (ft AMSL)	Bottom of Screen Elevation (ft AMSL)	Groundwater Elevation (ft AMSL)	Top of Bedrock Elevation (ft AMSL)	Saturated Alluvial Thickness(1) (ft)	Depth to Water (ft-BTOC)	Water Level Measurement Date
	Easting	Northing										
P219189	2084010	751222	Qc	UHSU	*	5934 1	5929 7	5933 4	5930 2	3 2	9 78	1-Apr-93
P219489	2085651	750415	Qrf	UHSU	*	5941 0	5936 6	5946 9	5937 0	9 9	14 28	1 Apr-93
P219589	2085536	750268	K(clst)	UHSU	**	5942 5	5938 1	5944 2	5946 6	-2 4	21 47	1-Apr-93

Explanation

Qal Quaternary alluvium (undifferentiated)
Qc Quaternary colluvium
Qrf Quaternary Rocky Flats Alluvium
Qvf Quaternary Valley-Fill Alluvium
K(clst) Cretaceous bedrock claystone
K (sltst) - Cretaceous bedrock siltstone
K(ss) - Cretaceous bedrock sandstone

UHSU - Upper Hydrostratigraphic Unit
LHSU - Lower Hydrostratigraphic Unit
BTOC - Below Top of Casing
AMSL - Above Mean Sea Level
NE - Not Encountered
NA - Not Available

(1) Negative saturated thickness indicates depth to groundwater below top of bedrock surface

(2) No borehole log available

* Wells screened in unconsolidated surface materials (Qal Qrf, Qc, Qvf) are considered to UHSU wells.
** Selection of hydrostratigraphic unit based on groundwater elevation.
*** Selection of hydrostratigraphic unit based on geochemistry (Stiff diagram - Figure 3 6-9)

TABLE 3 6-2
ESTIMATED HYDRAULIC CONDUCTIVITY OF UHSU MATERIAL BASED ON 1986 AND 1987 AQUIFER TESTS

Site/Well Number	Geologic Unit of Screened Interval	Soil/Lithology Type	Hydraulic Conductivity from Aquifer Test (cm/sec)	Test Type	Data Source
1486	K(ss clst,sltst)	Slightly weathered silty claystone siltstone sandstone	1 3E-06*	Packer	(2)
1586	Qvf	Silty clay with gravel silty claystone	4 3E-05	Recovery	(2)
1786	Qvf/K(clst)	Gravel and claystone	4 8E-06	Airlifts/slug	(2)
2786	K(clst/sltst)	Claystone and siltstone	1 7E-06*	Packer	(2)
3086	K(clst)	Claystone	8 6E-07	Recovery	(2)
3586	Qvf	Silty sandy clay	1 4E-04	Slug	(2)
6087	Qrf	Sand and gravel, grading to clayey sand and clay	1 3E-03	Slug	(1)
6187	Qrf	Sand	9 9E-04	Slug	(1)
6287	Qrf	Sand and gravel clayey sand and clay	6 2E-04	Slug	(1)
6387	Qrf	Sand and gravel, sandy clay	6 7E-04	Slug	(1)
6587	Qrf	Clayey sand	4 6E-04	Slug	(1)
6687	Qrf	Sand and sandy clay	1 8E-04	Slug	(1)
6787	Qrf	Clayey sand	6 4E-05	Slug	(1)
7187	Qrf	Clayey sand grading to sandy clay	6 6E-04	Slug	(1)

Explanation
Qvf Quaternary Valley-Fill Alluvium
Qrf - Quaternary Rocky Flats Alluvium
K(ss) - Cretaceous sandstone
K(clst/sltst) - Cretaceous claystone and/or siltstone
cm/sec centimeter per second
* - Geometric mean from Packer test results

Data Sources
1 Rockwell International (1988b)
2 Rockwell International (1988c)

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

WELL 1386 (UHSU)

Sample Date 4/13/93

--Cations--	Measured Concentration (mg/L)	mmole/L	meq/L	% meq/L
Calcium (Ca^{+2})	123	3 0689	6.14	41 66
Magnesium (Mg^{+2})	41 6	1 7114	3 42	23 23
Potassium (K^{+})	1 56	0 0399	0 04	0 27
Sodium (Na^{+})	118	5 1330	5.13	34 84
Iron (Fe^{+2})	0 005	0 0001	0 00	0 00
			14 73	
--Anions--				
Bicarbonate (HCO_3^-)	530	8 6867	8.69	66 09
Carbonate ($CO3^{2}$)	10	0 1666	0.33	2 54
Chloride (Cl^-)	82	2 3132	2.31	17 60
Sulfate ($SO4^{2}$)	87	0 9057	1.81	13 78
			13 14	
Cation/Anion Balance	5 70%			
TDS Calculated (mg/L)	993 17			

Well 1486 (LHSU)

Sample Date 4/13/93

--Cations--	Measured Concentration (mg/L)	mmole/L	meq/L	% meq/L
Calcium (Ca^{+2})	156	3 8922	7 78	52 83
Magnesium (Mg^{+2})	46 6	1 9171	3.83	26 03
Potassium (K^{+})	6 26	0 1601	0.16	1 09
Sodium (Na^{+})	229	9 9615	9 96	67 61
Iron (Fe^{+2})	0 005	0 0001	0 00	0 00
			21 74	
--Anions--				
Bicarbonate (HCO_3^-)	370	6 0643	6.06	46 14
Carbonate ($CO3^{2}$)	10	0 1666	0 33	2 54
Chloride (Cl^-)	84	2 3696	2.37	18 03
Sulfate ($SO4^{2}$)	560	5 8296	11 66	88 70
			20 43	
Cation/Anion Balance.	3 12%			
TDS Calculated (mg/L)	1461 87			

Explanation

UHSU- Upper hydrostratigraphic unit
LHSU- Lower hydrostratigraphic unit
TDS- Total dissolved solids

mg/L - milligrams/liter
mmole/L - millimoles/liter
meq/L - milliequivalents/liter

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

Well 1586 (UHSU)

Sample Date 4/13/93

--Cations--	Measured Concentration (mg/L)	mmole/L	meq/L	% meq/L
Calcium (Ca^{+2})	191	4 7655	**9 53**	51 14
Magnesium (Mg^{+2})	47 1	1 9377	**3 88**	20 80
Potassium (K^{+})	2 06	0 0527	**0 05**	0 28
Sodium (Na^{+})	119	5 1765	**5.18**	27 78
Iron (Fe^{+2})	0 0069	0 0001	**0.00**	0 00
			18 64	
--Anions--				
Bicarbonate (HCO_3^-)	380	6 2282	**6 23**	48 99
Carbonate ($CO3^{2}$)	10	0 1666	**0.33**	2 62
Chloride (Cl)	100	2 8210	**2.82**	22 19
Sulfate ($SO4^{2}$)	160	1 6656	**3.33**	26 20
			12 71	
Cation/Anion Balance	19%			
TDS Calculated (mg/L)	1009 17			

Well 1686 (LHSU)

Sample Date 4/23/93

--Cations--	Measured Concentration (mg/L)	mmole/L	meq/L	% meq/L
Calcium (Ca^{+2})	140	3 4930	**6 99**	37 49
Magnesium (Mg^{+2})	44 8	1 8431	**3.69**	19 78
Potassium (K^{+})	7 31	0 1870	**0 19**	1 00
Sodium (Na^{+})	248	10 7880	**10 79**	57 89
Iron (Fe^{+2})	0 0042	0 0001	**0 00**	0 00
			21 65	
--Anions--				
Bicarbonate (HCO_3)	360	5 9004	**5 90**	46 41
Carbonate ($CO3^{2}$)	1	0 0167	**0 03**	0 26
Chloride (Cl)	380	10 7198	**10 72**	84 32
Sulfate ($SO4^{2}$)	450	4 6845	**9 37**	73 69
			26 02	
Cation/Anion Balance	-9 18%			
TDS Calculated (mg/L)	1631 11			

Explanation

UHSU- Upper hydrostratigraphic unit
LHSU- Lower hydrostratigraphic unit
TDS- Total dissolved solids

mg/L - milligrams/liter
mmole/L - millimoles/liter
meq/L - milliequivalents/liter

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

Well 1986 (UHSU)

Sample Date 2/12/93

--Cations--	Measured Concentration (mg/L)	mmole/L	meq/L	% meq/L
Calcium (Ca^{+2})	114	2 8443	5.69	33 87
Magnesium (Mg^{+2})	34 2	1 4070	2.81	16 76
Potassium (K^{+})	1 8	0 0460	0.05	0 27
Sodium (Na^{+})	182	7 9170	7 92	47 13
Iron (Fe^{+2})	9 24	0 1655	0.33	1 97
			16 80	
--Anions--				
Bicarbonate (HCO_3^-)	650	10 6535	10.65	76 09
Carbonate ($CO3^{2}$)	1	0 0167	0.03	0 24
Chloride (Cl^-)	85	2 3979	2.40	17 13
Sulfate ($SO4^{2}$)	44	0 4580	0.92	6 54
			14 00	
Cation/Anion Balance	9 08%			
TDS Calculated (mg/L)	1121 24			

WELL 4287 (UHSU)

Sample Date 5/11/93

--Cations--	Measured Concentration (mg/L)	mmole/L	meq/L	% meq/L
Calcium (Ca^{+2})	95 3	2 3777	4 76	28 31
Magnesium (Mg^{+2})	14 3	0 5883	1 18	7 01
Potassium (K^{+})	1 08	0 0276	0 03	0 16
Sodium (Na^{+})	32 2	1 4007	1 40	8 34
Iron (Fe^{+2})	0 0238	0 0004	0 00	0 01
			7 36	
--Anions--				
Bicarbonate (HCO_3^-)	280	4 5892	4.59	32 78
Carbonate ($CO3^{2}$)	10	0 1666	0 33	2 38
Chloride (Cl^-)	14	0 3949	0.39	2 82
Sulfate ($SO4^{2}$)	33	0 3435	0 69	4 91
			6 00	
Cation/Anion Balance	10 15%			
TDS Calculated (mg/L)	479 90			

Explanation.

UHSU- Upper hydrostratigraphic unit
LHSU- Lower hydrostratigraphic unit
TDS- Total dissolved solids

mg/L - milligrams/liter
mmole/L - millimoles/liter
meq/L - milliequivalents/liter

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

Well 6487 (UHSU)

Sample Date 4/12/93

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	77 4	1 9311	**3 86**	56 20
Magnesium (Mg^{+2})	13 4	0 5513	**1 10**	16 05
Potassium (K^{+})	1 5	0 0384	**0 04**	0 56
Sodium (Na^{+})	27 9	1 2137	**1 21**	17 66
Iron (Fe^{+2})	18 3	0 3278	**0 66**	9 54
			6 87	
--Anions--				
Bicarbonate* (HCO_3)	200	3 2780	**3 28**	58 69
Carbonate ($CO3^{2}$)	10	0 1666	**0 33**	5 97
Chloride* (Cl^{-})	53	1 4951	**1 50**	26 77
Sulfate* ($SO4^{2}$)	23	0 2394	**0 48**	8 57
			5 59	
Cation/Anion Balance	10 33%			
TDS Calculated (mg/L)	424 50			

* Anion data from 4/9/93

Well 7187 (UHSU)

Sample Date 4/9/93

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	71 4	1 7814	**3 56**	51 84
Magnesium (Mg^{+2})	7 97	0 3279	**0 66**	9 54
Potassium (K^{+})	0 422	0 0108	**0 01**	0 16
Sodium (Na^{+})	8	0 3480	**0 35**	5 06
Iron (Fe^{+2})	0 03	0 0005	**0 00**	0 02
			4 58	
--Anions--				
Bicarbonate (HCO_3)	200	3 2780	**3 28**	58 69
Carbonate ($CO3^{2}$)	1	0 0167	**0 03**	0 60
Chloride (Cl)	2 5	0 0705	**0 07**	1 26
Sulfate ($SO4^{2}$)	27	0 2811	**0 56**	10 06
			3 94	
Cation/Anion Balance	7 45%			
TDS Calculated (mg/L)	318 32			

Explanation

UHSU- Upper hydrostratigraphic unit
LHSU- Lower hydrostratigraphic unit
TDS- Total dissolved solids

mg/L milligrams/liter
mmole/L - millimoles/liter
meq/L - milliequivalents/liter

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

Well 7287 (UHSU)

Sample Date 4/9/93

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	69 6	1 7365	**3 47**	68 57
Magnesium (Mg^{+2})	11 8	0 4855	**0 97**	19 17
Potassium (K^{+})	0 422	0 0108	**0 01**	0 21
Sodium (Na^{+})	14	0 6090	**0 61**	12 02
Iron (Fe^{+2})	0 03	0 0005	**0 00**	0 02
			5 06	
--Anions--				
Bicarbonate (HCO_3^-)	210	3.4419	**3 44**	72 70
Carbonate ($CO3^{2}$)	1	0 0167	**0 03**	0 70
Chloride (Cl^-)	7	0 1975	**0 20**	4 17
Sulfate ($SO4^{2}$)	51	0 5309	**1 06**	22 43
			4 73	
Cation/Anion Balance	3 37%			
TDS Calculated (mg/L)	364 85			

Well B206189 (UHSU)

Sample Date 3/12/91

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	123	3 0689	**6.14**	121 18
Magnesium (Mg^{+2})	23 4	0 9627	**1 93**	38 02
Potassium (K^{+})	3 15	0.0806	**0 08**	1 59
Sodium (Na^{+})	118	5 1330	**5 13**	101 34
Iron (Fe^{+2})	0 0317	0 0006	**0.00**	0 02
			13 28	
--Anions--				
Bicarbonate (HCO_3^-)	442	7 2444	**7 24**	153 01
Carbonate ($CO3^{2}$)	10	0 1666	**0.33**	7 04
Chloride (Cl^-)	62 4	1 7603	**1 76**	37 18
Sulfate ($SO4^{2}$)	86 5	0 9005	**1.80**	38 04
			11 14	
Cation/Anion Balance	8 76%			
TDS Calculated (mg/L)	868 48			

Explanation.

UHSU- Upper hydrostratigraphic unit
LHSU- Lower hydrostratigraphic unit
TDS- Total dissolved solids

mg/L - milligrams/liter
mmole/L - millimoles/liter
meq/L - milliequivalents/liter

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

Well B206589 (UHSU)

Sample Date 4/16/93

- **Cations**	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	98 5	2 4576	**4 92**	47 09
Magnesium (Mg^{+2})	29 9	1 2301	**2 46**	23 57
Potassium (K^{+})	3 42	0 0875	**0 09**	0 84
Sodium (Na^{+})	68 4	2 9754	**2 98**	28 50
Iron (Fe^{+2})	0 0073	0 0001	**0 00**	0 00
			10 44	
Anions-				
Bicarbonate *(HCO_3)	360	5 9004	**5 90**	64 19
Carbonate ($CO3^{2}$)	1	0 0167	**0 03**	0 36
Chloride*(Cl)	69	1 9465	**1 95**	21 18
Sulfate *($SO4^{2}$)	63	0 6558	**1 31**	14 27
			9 19	
Cation/Anion Balance	6 35%			
TDS Calculated (mg/L)	693 23			

*Anion data from 2/2/93 sample

Well B206689 (UHSU)

Sample Date 4/21/93

- **Cations**	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	89 6	2 2355	**4 47**	42 83
Magnesium (Mg^{+2})	26 8	1 1026	**2 21**	21 13
Potassium (K^{+})	1 73	0 0443	**0 04**	0 42
Sodium (Na^{+})	77 8	3 3843	**3 38**	32 42
Iron (Fe^{+2})	5	0 0896	**0 18**	1 72
			10 28	
Anions				
Bicarbonate (HCO_3)	250	4 0975	**4 10**	44 58
Carbonate ($CO3^{2}$)	10	0 1666	**0 33**	3 63
Chloride (Cl)	75	2 1158	**2 12**	23 02
Sulfate ($SO4^{2}$)	130	1 3533	**2 71**	29 45
			9 25	
Cation/Anion Balance	5 28%			
TDS Calculated (mg/L)	665 93			

Explanation.

UHSU	Upper hydrostratigraphic unit	mg/L	milligrams/liter
LHSU	Lower hydrostratigraphic unit	mmole/L	millimoles/liter
TDS	Total dissolved solids	meq/L	milliequivalents/liter

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

Well B207089 (LHSU)

Sample Date 4/20/93

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	154	3 8423	7 68	23 86
Magnesium (Mg^{+2})	46 4	1 9089	3 82	11 85
Potassium (K^{+})	6 97	0 1783	0.18	0 55
Sodium (Na^{+})	472	20 5320	20 53	63 74
Iron (Fe^{+2})	0 005	0 0001	0 00	0 00
			32 21	
--Anions--				
Bicarbonate (HCO_3^-)	370	6 0643	6 06	19 37
Carbonate ($CO3^{-2}$)	10	0 1666	0.33	1 06
Chloride (Cl^-)	470	13 2587	13 26	42 34
Sulfate ($SO4^{-2}$)	560	5 8296	11.66	37 23
			31 32	
Cation/Anion Balance	1 41%			
TDS Calculated (mg/L)	2089 38			

Well B208789 (UHSU)

Sample Date 4/9/92

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	131 5	3 2809	6 56	20 37
Magnesium (Mg^{+2})	35 9	1 4769	2.95	9 17
Potassium (K^{+})	0 646	0 0165	0.02	0 05
Sodium (Na^{+})	125 5	5 4593	5.46	16 95
Iron (Fe^{+2})	0 0071	0 0001	0.00	0 00
			14 99	
--Anions--				
Bicarbonate (HCO_3^-)	390	6 3921	6.39	20 41
Carbonate ($CO3^{2}$)	1	0 0167	0 03	0 11
Chloride (Cl^-)	130	3 6673	3 67	11 71
Sulfate ($SO4^{2}$)	190	1 9779	3 96	12 63
			14 05	
Cation/Anion Balance	3 25%			
TDS Calculated (mg/L)	1004 55			

Explanation.

UHSU- Upper hydrostratigraphic unit
LHSU- Lower hydrostratigraphic unit
TDS- Total dissolved solids

mg/L - milligrams/liter
mmole/L - millimoles/liter
meq/L - milliequivalents/liter

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

Well P210089 (LHSU)

Sample Date 4/23/93

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	440	10 9780	**21 96**	47 35
Magnesium (Mg^{+2})	123	5 0602	**10 12**	21 83
Potassium (K^{+})	7 85	0 2008	**0 20**	0 43
Sodium (Na^{+})	324	14 0940	**14 09**	30 39
Iron (Fe^{+2})	0 002	0 0000	**0 00**	0 00
			46 37	
--Anions--				
Bicarbonate (HCO_3^-)	130	2 1307	**2 13**	3 45
Carbonate ($CO3^{2}$)	1	0 0167	**0 03**	0 05
Chloride (Cl^-)	1300	36 6730	**36 67**	59 40
Sulfate ($SO4^{2}$)	1100	11 4510	**22 90**	37 09
			61 74	
Cation/Anion Balance	14 21%			
TDS Calculated (mg/L)	3425 85			

Well B210389 (LHSU)

Sample Date 4/20/93

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca)	154	3 8423	**7 68**	16 57
Magnesium (Mg)	46 4	1 9089	**3 82**	8 23
Potassium (K^{+})	6 97	0 1783	**0 18**	0 38
Sodium (Na)	472	20 5320	**20 53**	44 28
Iron* (Fe^{+})			0 00	
			32 21	
--Anions--				
Bicarbonate (HCO_3)	370	6 0643	**6 06**	9 82
Carbonate ($CO3^{2}$)	10	0 1666	**0 33**	0 54
Chloride (Cl)	470	13 2587	**13 26**	21 48
Sulfate ($SO4^{2}$)	560	5 8296	**11 66**	18 88
			31 32	
Cation/Anion Balance	1 41%			
TDS Calculated (mg/L)	2089 37			

* No data for Fe^{+2}

Explanation

UHSU Upper hydrostratigraphic unit
LHSU- Lower hydrostratigraphic unit
TDS- Total dissolved solids

mg/L - milligrams/liter
mmole/L millimoles/liter
meq/L milliequivalents/liter

TABLE 3 6-3
STIFF DIAGRAM GROUNDWATER DATA

Well 76292 (UHSU)

Sample Date 4/21/93

--Cations--	Measured Concentration (mg/L)	meq/L	% meq/L	% meq/L
Calcium (Ca^{+2})	79 8	1 9910	**3 98**	62 25
Magnesium (Mg^{+2})	15 9	0 6541	**1.31**	20 46
Potassium (K^{+})	3 94	0 1008	**0.10**	1 58
Sodium (Na^{+})	23 1	1 0049	**1 00**	15 71
Iron (Fe^{+2})	0 0072	0 0001	**0 00**	0 00
			6 40	
--Anions--				
Bicarbonate (HCO_3^-)	170	2 7863	**2.79**	66 45
Carbonate ($CO3^{2}$)	10	0 1666	**0.33**	7 95
Chloride (Cl^-)	10	0 2821	**0 28**	6 73
Sulfate ($SO4^{2}$)	38	0 3956	**0 79**	18 87
			4 19	
Cation/Anion Balance	20 81%			
TDS Calculated (mg/L)	350 75			

Explanation

UHSU- Upper hydrostratigraphic unit
LHSU- Lower hydrostratigraphic unit
TDS- Total dissolved solids

mg/L - milligrams/liter
mmole/L - millimoles/liter
meq/L - milliequivalents/liter

TABLE 3 7-1
OU6 POND CAPACITY AND TOTAL RUNOFF VOLUME
(EG&G 1992c)

OU6 Ponds	Drainage Basin Area (acres)	Total Pond Capacity* (acre-feet)	Volume of Runoff** in acre-feet (% of total pond capacity): 25-year, 6-hour event	100-year, 6-hour event	100-year, 10-day event
A 3		38			
A-4		100			
A 3 and A-4 combined	380	138	44 (32%)	64 (46%)	66 (48%)
B-4 and B-5 combined***	340	74	52 (70%)	71 (96%)	108 (146%)

* Capacity at spillway crest elevation based on stage storage curves by Merrick and Company dated 7/23/91
** Estimated with the Colorado Urban Hydrograph Procedure
*** Pond B-4 is a flow-through pond therefore individual pond capacities are not listed

TABLE 3 7 2
WALNUT CREEK BASIN-WIDE
CHARACTERISTICS UPSTREAM OF INDIANA STREET

Area	3 71 mi^2
Basin Length	5 7 mi
Basin Slope	0 027 ft/ft
Impervious Existing	14 percent
Pervious Retention	0 49 in
Impervious Retention	0 10 in
Infiltration, Initial	3 75 in/hr
Infiltration, Final	0 55 in/hr

From EG&G 1993b

TABLE 3 7-3
FLOW VOLUMES AND RUNOFF COEFFICIENTS
FOR OU6 GS10 AND GS03

	Flow Volumes in Mgal/Month		Runoff Coefficient (Mgal/sq mi)	
Measurement Date	**GS10**	**GS03**	**GS10**	**GS03**
Jul-91	5 30	3 42	15 13	0 92
Aug-91	1 95	10 26	5 58	2 77
Sep-91	1 85	9 87	5 28	2 67
Oct-91	1 11	5 94	3 18	1 61
Feb-92	5 36	2 52	15 31	0 68
Mar-92	8 77	76 72	25 07	20 73
Apr-92	2 71	19 50	7 75	5 27
May-92	1 63	0 07	4 67	0 02
Oct-92	0 36	3 78	1 03	1 02
Nov-92	0 86	0 00	2 47	0 00
Dec-92	0 81	12 31	2 32	3 33
Apr-93	3 36	34 26	9 59	9 26
Jun-93	1 64	6 09	4 68	1 65
Jul-93	0 83	6 73	2 38	1 82
Aug-93	0 70	10 00	2 00	2 70
Sums	37 25	201 47	106 43	54 45

Explanation
GS - gauging station
Mgal - millions of gallons
sq mi - square mile

TABLE 3 9-1
WALNUT CREEK DRAINAGE BASIN CHARACTERISTICS[1]

IHSS	Drainage Basin Designation[2]	Impervious Area (%)	Initial Infiltration (In/Hr)	Basin Slope (Ft/Ft)
141	SWA3	3	2 00	0 020
	CSWAB	78	4 20	0 024
142 1-4	WA11	5	1 30	0 028
142 5-8	SWA3	3	2 00	0 020
142 9	SWA1	7	1 00	0 057
142 12	WA1	1	1 50	0 015
143	CWAC	66	4 30	0 031
156 2	SWA3	3	2 00	0 020
	WA11	5	1 30	0 028
	CWAB	50	6 00	0 032
	CSWAB	78	4 20	0 024
165	CWAB	50	6 00	0 032
	CSWAB	78	4 20	0 024
166 1	WA7	6	3 50	0 037
166 2	WA13	25	4 00	0 032
166 3	WA13	25	4 00	0 032
	WA6	0	1 50	0 039
167 1	WA6	0	1 50	0 039
167 2-3	WA7	6	3 50	0 037
216 1	WA11	5	1 30	0 028
	SWA3	3	2 00	0 020

Notes

IHSS - Individual Hazardous Substance Site
In/Hr - inches per hour
Ft/Ft - feet per foot

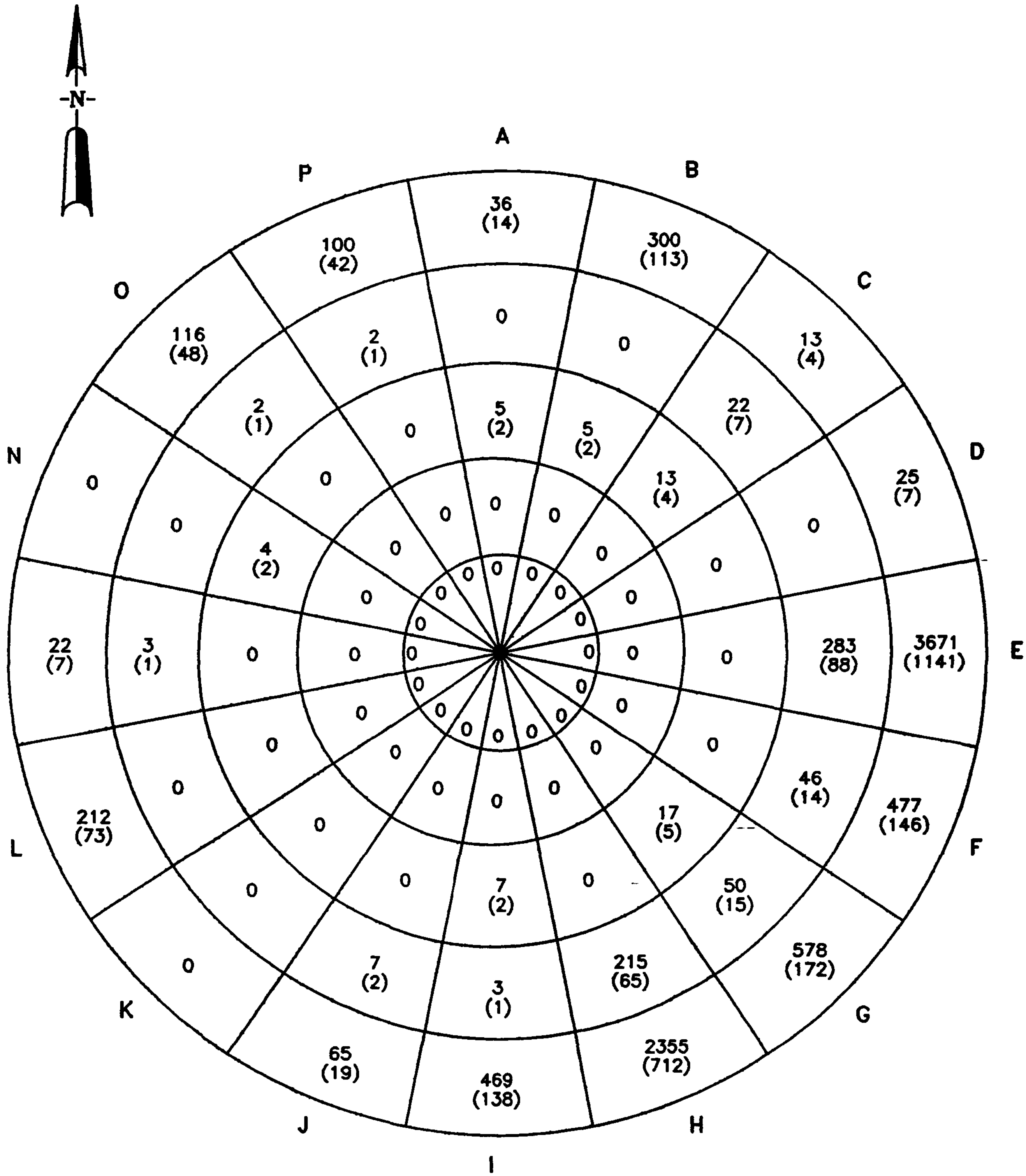
1 Source RFP Drainage and Flood Control Master Plan (EG&G 1992c)
2 Refer to Figure 3 7-1 for the delineation of each drainage basin

TABLE 3 9-2
OU6 PONDS[1]
IHSSs 142 1 THROUGH 142 9

OU6 IHSS	Pond	Pond Volume at 100% Capacity (Mgal)	Elevation at 100% Capacity (Feet)	Approximate Surface Area at 100% Capacity (Acres)
142 1	A-1	1 4	5829 1 (drop structure)	1 09
142 2	A-2	6 0	5816 9 (drop structure)	2 47
142 3	A-3	12 37	5793 0 (spillway crest)	4 61
142 4	A-4	32 49	5757 9 (spillway crest)	8 68
142 5	B-1	1 14	5882 0 (spillway crest)	0 94
142 6	B-2	1 50	5868 9 (drop structure)	0 98
142 7	B-3	0 57	5851 7 (spillway crest)	0 55
142 8	B-4	0 18	5835 8 (spillway crest)	0 38
142 9	B-5	24 65	5803 9 (spillway crest)	6 05

Notes
IHSS - Individual Hazardous Substance Site
Mgal - millions of gallons

[1] Pond volumes, elevations and surface areas are from Detention Pond Capacity Study (Merrick 1992)



EXPLANATION

MILES	SECTOR NAME	MILES	SECTOR NAME
0–1	SECTOR 1	3–4	SECTOR 4
1–2	SECTOR 2	4–5	SECTOR 5
2–3	SECTOR 3		

469 – POPULATION IN SPECIFIED SECTOR

(138) – NUMBER OF HOUSEHOLDS LOCATED WITHIN SPECIFIED SECTOR

SECTOR – RADIUS REPRESENTING NUMBER OF MILES FROM THE CENTER OF RFETS

SOURCE DOE 1990 b

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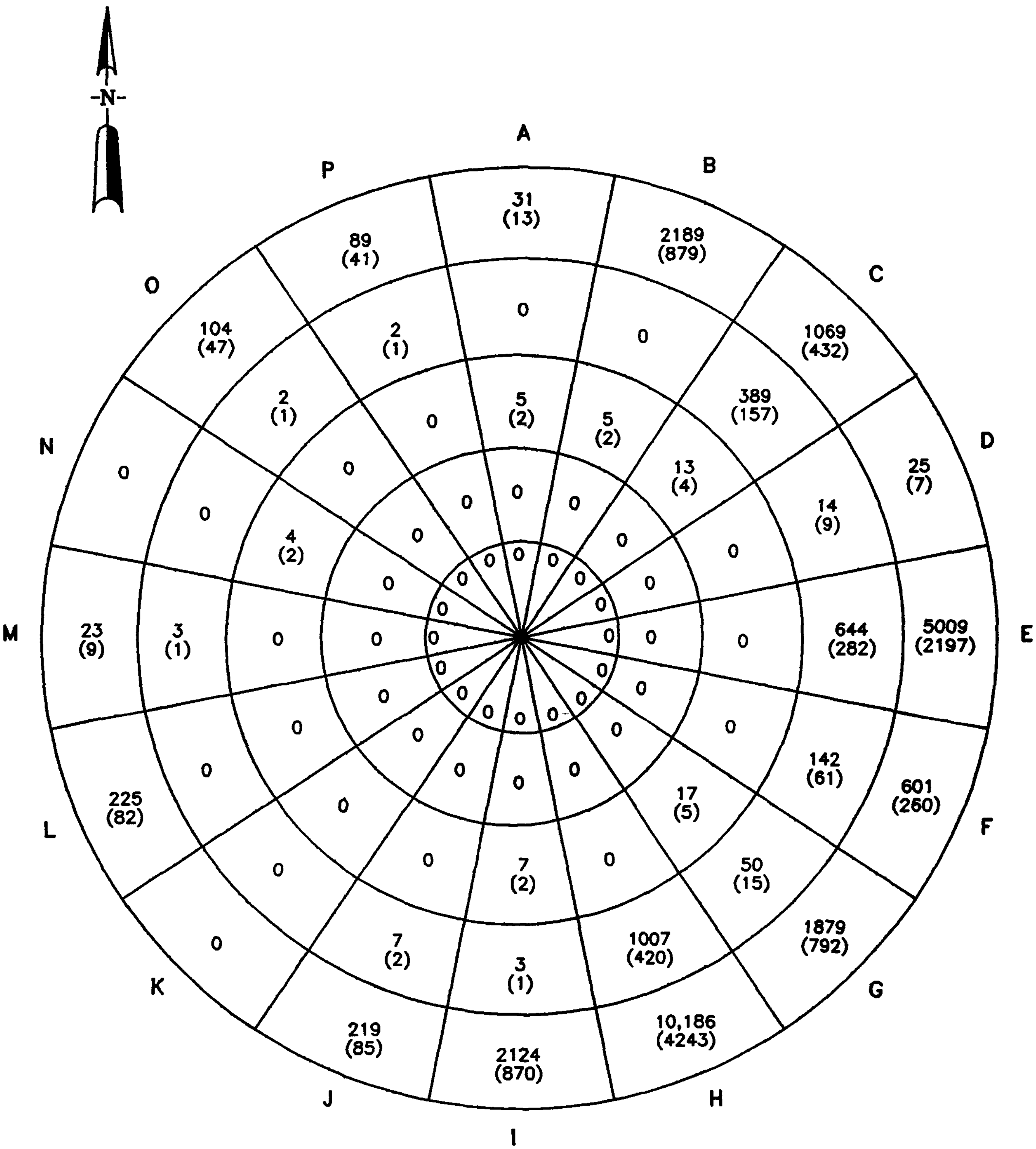
1989 POPULATION AND (HOUSEHOLDS) SECTOR 1–5

FIGURE 3.2–1 APRIL 1995

0U6R001 1=1



EXPLANATION

MILES	SECTOR NAME	MILES	SECTOR NAME
0–1	SECTOR 1	3–4	SECTOR 4
1–2	SECTOR 2	4–5	SECTOR 5
2–3	SECTOR 3		

469 – POPULATION IN SPECIFIED SECTOR

(138) – NUMBER OF HOUSEHOLDS LOCATED WITHIN SPECIFIED SECTOR

SECTOR – RADIUS REPRESENTING NUMBER OF MILES FROM THE CENTER OF RFETS

SOURCE DOE 1990 b

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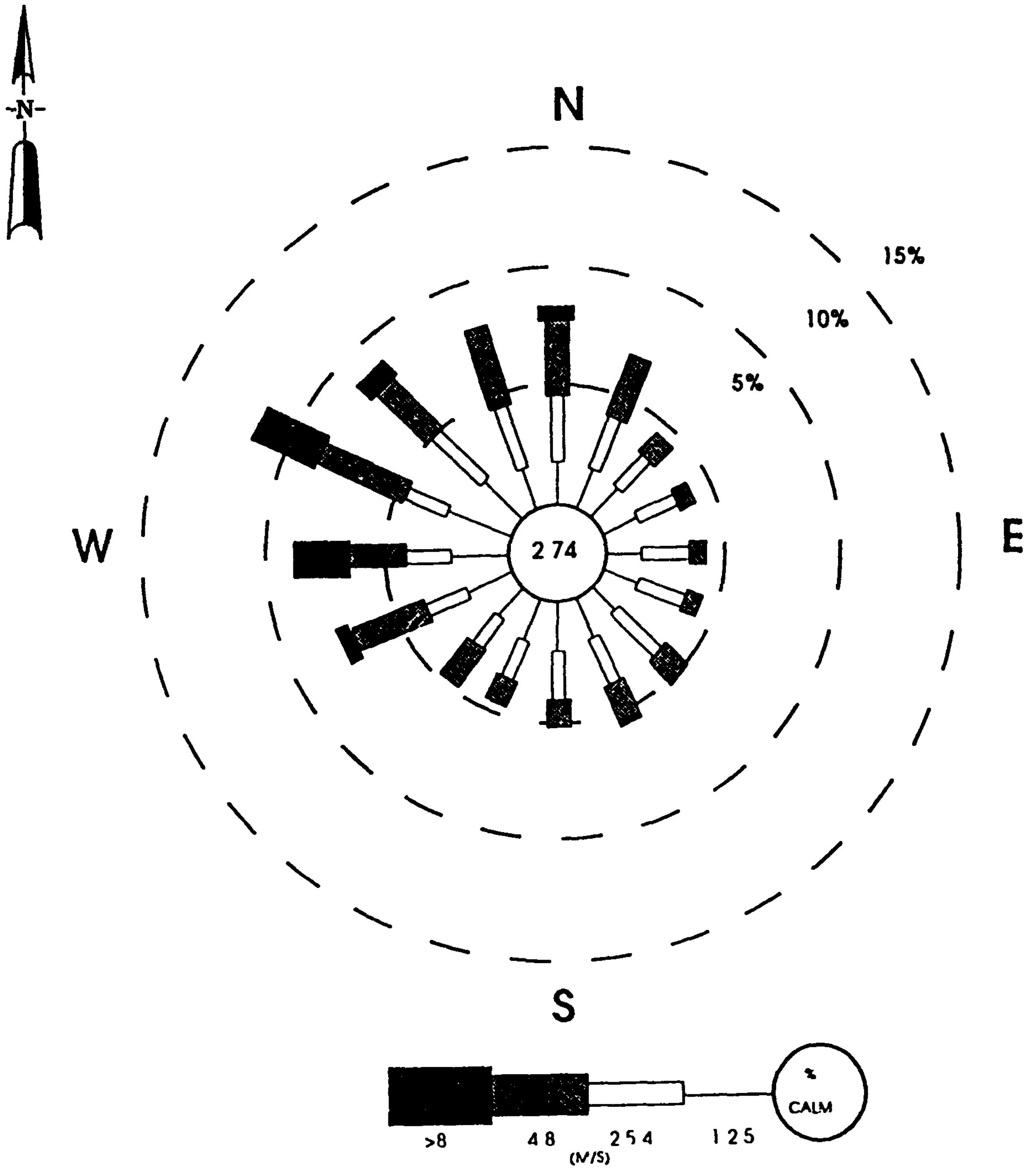
PROJECTED 2010 POPULATION AND (HOUSEHOLDS) SECTOR 1–5

FIGURE 3 2–2 APRIL 1995

OU6R082 1=1



M/S – METERS PER SECOND

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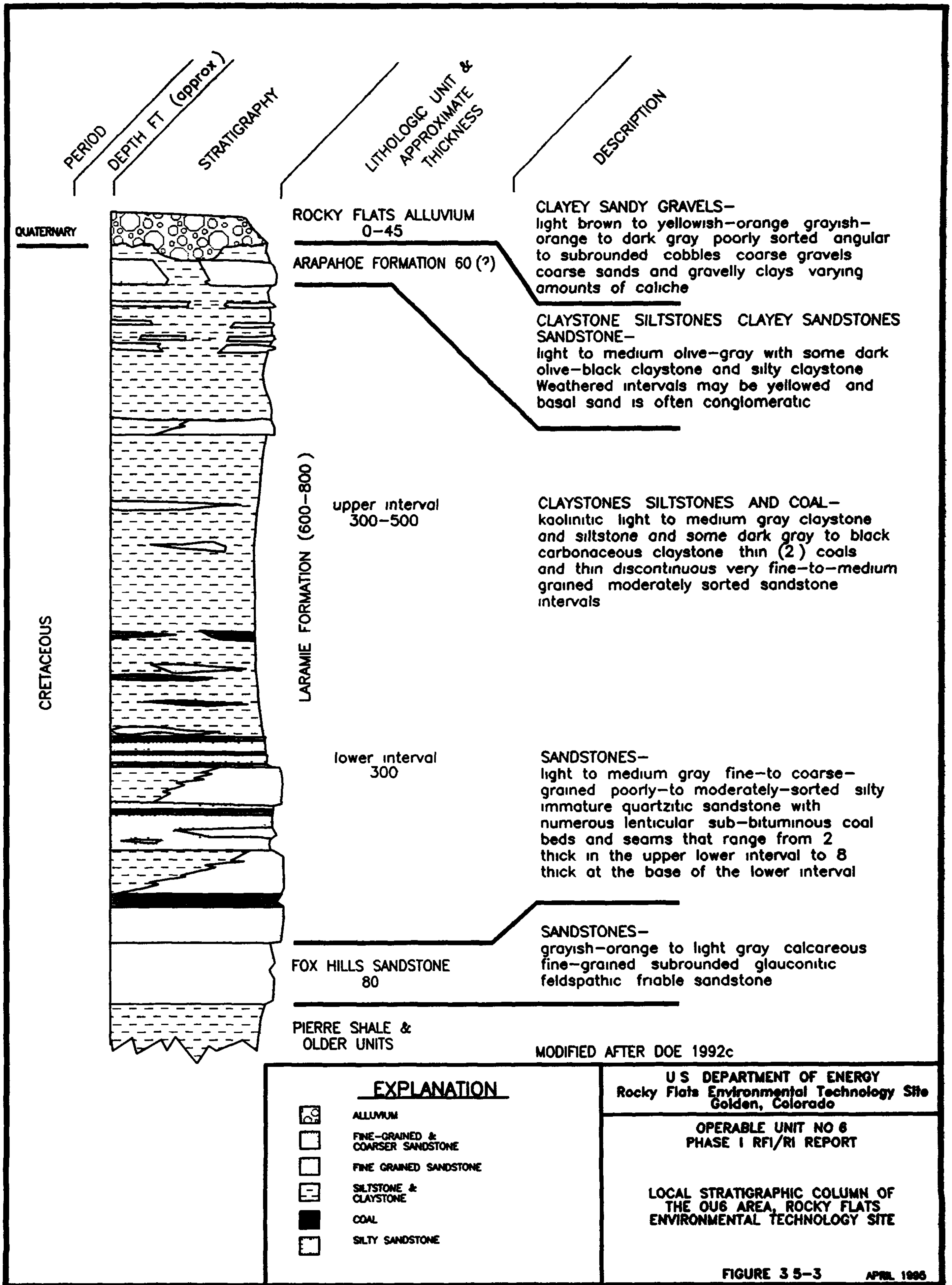
1993 ANNUAL WIND ROSE
FOR THE ROCKY FLATS
ENVIRONMENTAL TECHNOLOGY SITE

SOURCE DOE 1993a

FIGURE 3.3–1

APRIL 1995



LOCAL STRATIGRAPHIC COLUMN OF THE OU6 AREA, ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

FIGURE 3 5-3

YEARS BEFORE PRESENT	EPOCH	GLACIAL SEQUENCE		DEPOSIT	
1000	HOLOCENE	Gannett Peak Stade		Post-Piney Creek Alluvium	Man-Made Deposits Colluvium Debris Fans Alluvial Fans Landslides Lake and Pond Sediments
2000		Interstade	Terrace Alluvium — Valley-Fill Alluvium in This Report	(Soil) Piney Creek Alluvium	
3000		Temple Lake Stade			
5000		"Altithermal Interval"		(Soil) Pre-Piney Creek Alluvium	
12 000	PLEISTOCENE	WISCONSIN: Pinedale Glaciation		(Soil) Broadway Alluvium	
60 000		WISCONSIN: Bull Lake Glaciation		Louviers Alluvium	
130 000					
250 000		Sangamon Interglaciation ILLINOIAN	Terrace and Pediment Alluvium — High Terrace Alluviums in This Report	(Soil) Slocum Alluvium	
600 000		Yarmouth Interglaciation KANSAN		(Soil) Verdos Alluvium	
1 000 000		Aftonian Interglaciation NEBRASKAN	Pediment Alluvium	(Soil) Rocky Flats Alluvium	
1 500 000	Pleistocene or Pliocene			Pre-Rocky Flats Alluvium (Located West of RFETS)	

(Modified From Van Horn 1976 and Scott 1965)

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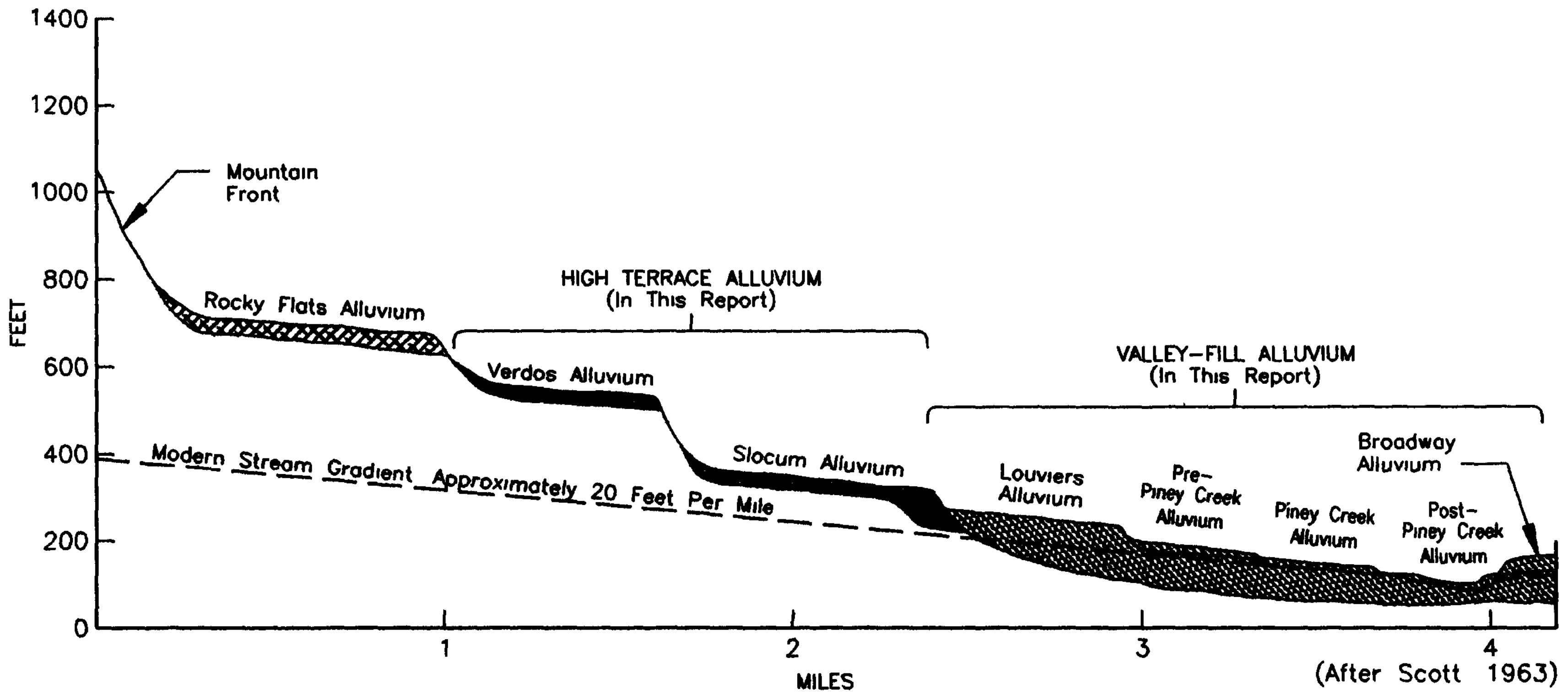
UNCONSOLIDATED SURFACE DEPOSITS IN THE AREA OF THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

FIGURE 3.5-4 APRIL 1995

0U6R085 1=1



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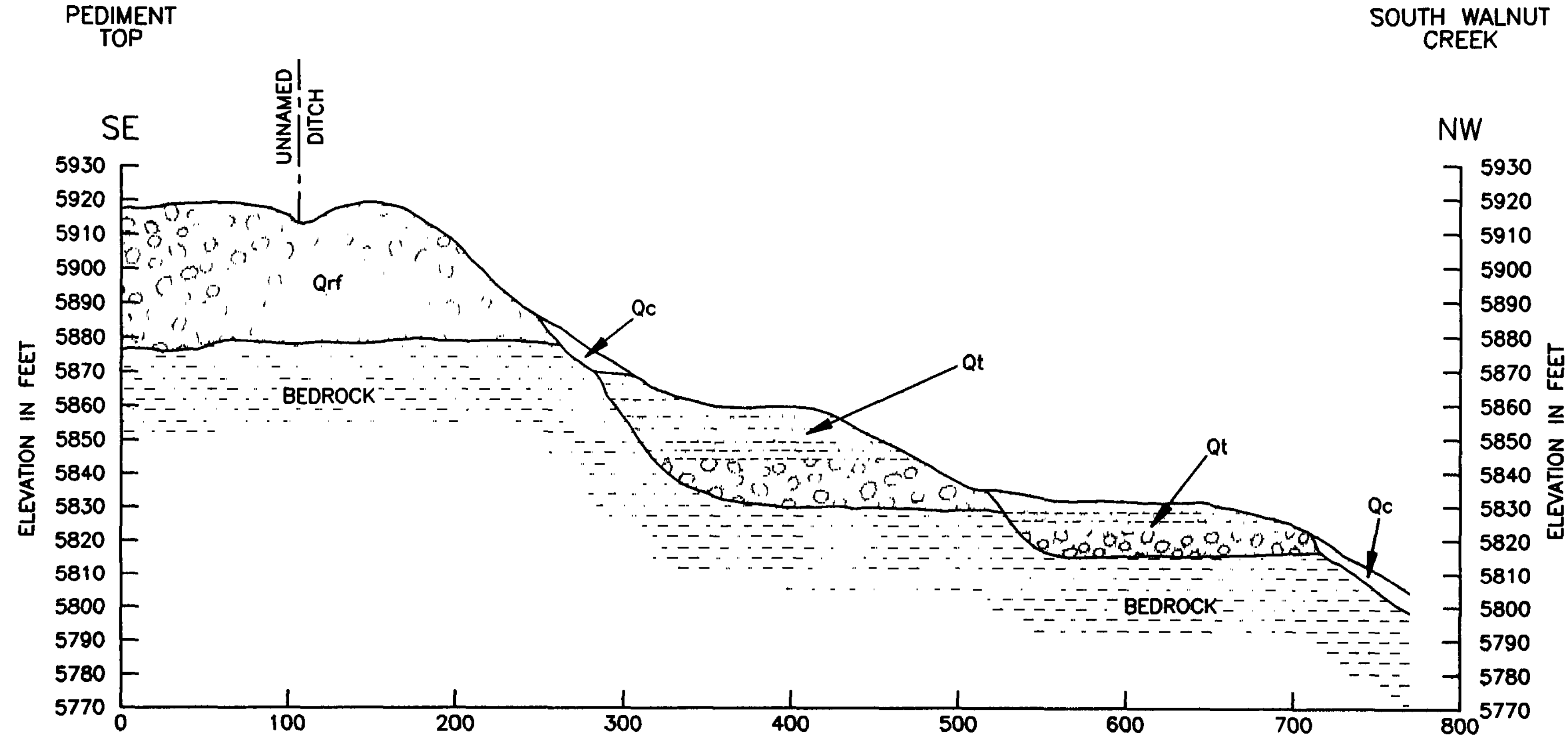
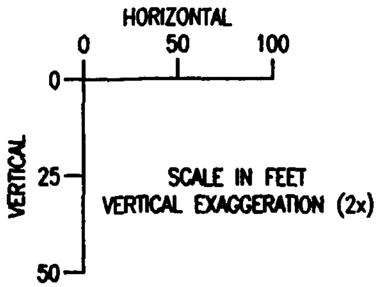
DIAGRAMMATIC CROSS SECTION SHOWING STRATIGRAPHIC RELATIONSHIPS OF QUATERNARY DEPOSITS IN THE VICINITY OF ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

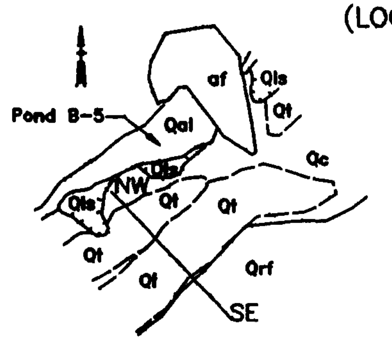
FIGURE 3.5-5 APRIL 1995

OU6R036 1=400



SE–NW CROSS SECTION
(LOOKING SOUTHWEST)





CROSS–SECTION LOCATION MAP

EXPLANATION

- GRAVEL
- SAND AND CLAY
- CLAYSTONE

QUATERNARY:
- Qrf — ROCKY FLATS ALLUVIUM
- Qt — HIGH TERRACE ALLUVIUM
- Qc — COLLUVIUM
- Qls — LANDSLIDES
- af — ARTIFICIAL FILL

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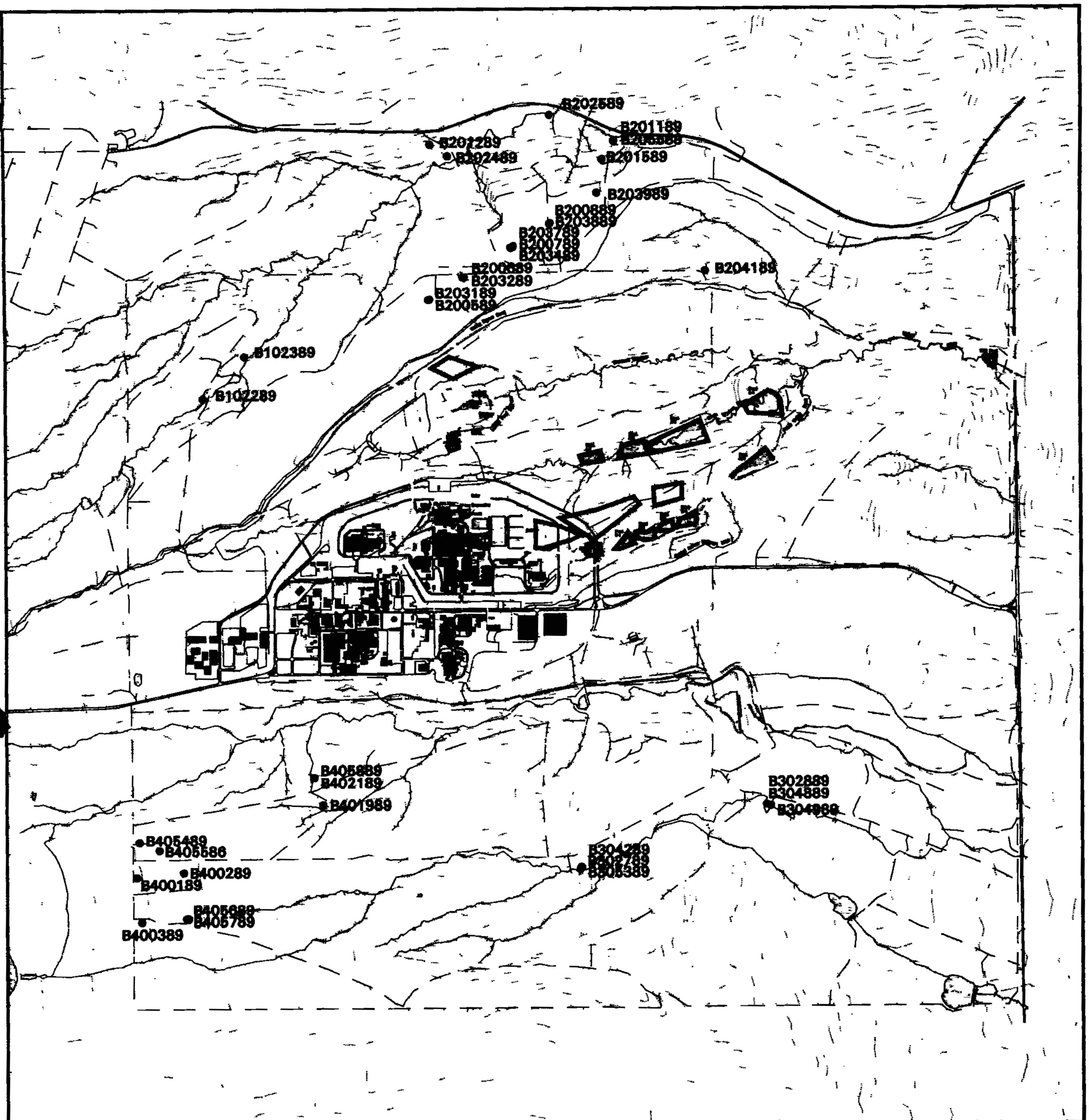
SCHEMATIC GEOLOGIC CROSS SECTION THROUGH TERRACE ALLUVIUMS ALONG SOUTH WALNUT CREEK HILLSIDE

FIGURE 3 5–6 APRIL 1995

5/17/95 OU6G097 1=100



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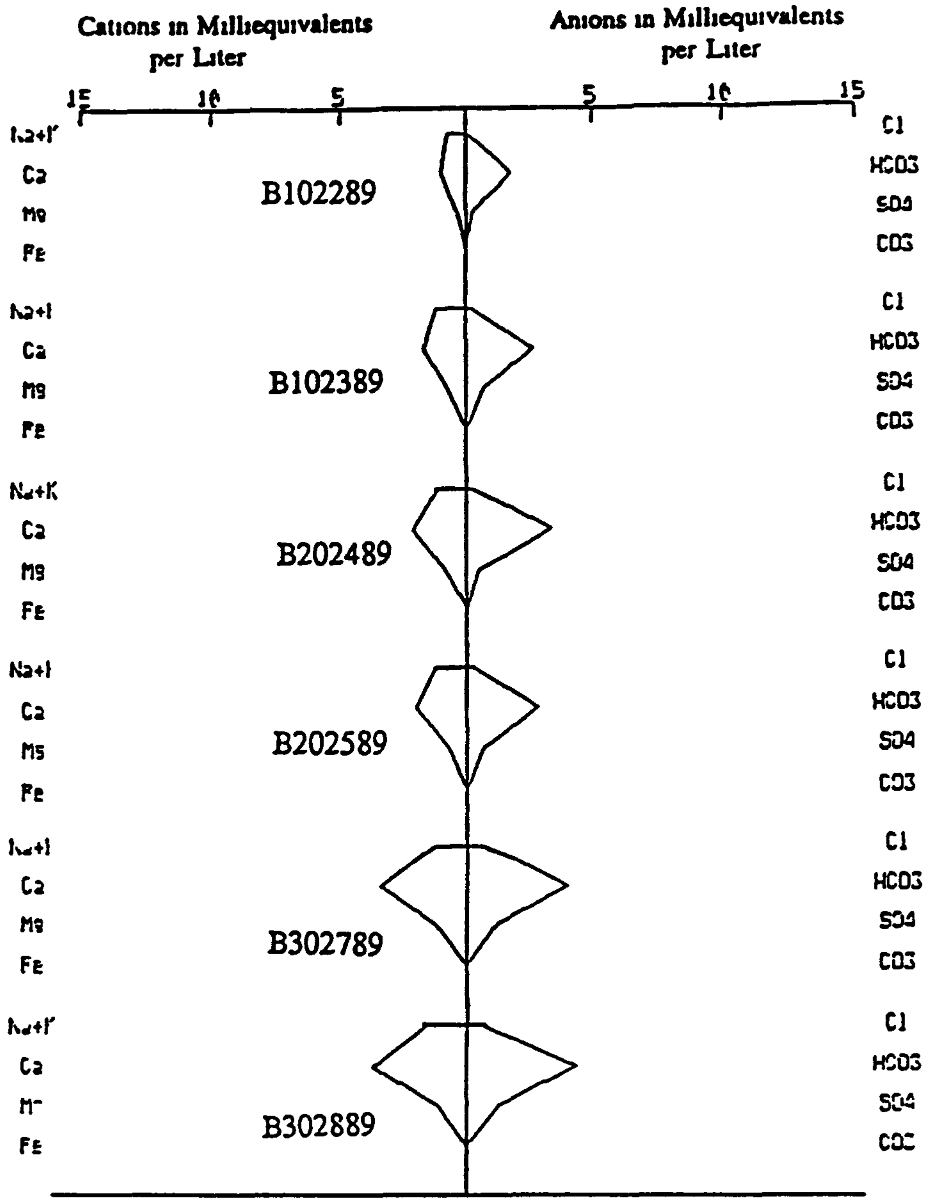
LOCATIONS OF BACKGROUND MONITORING WELLS USED IN STIFF DIAGRAM EVALUATION

FIGURE 3.6-3

APRIL 1995



GROUNDWATER IN VALLEY-FILL ALLUVIUM (VFA)

EXPLANATION

Na = SODIUM
K = POTASSIUM
Ca = CALCIUM
Mg = MAGNESIUM
Fe = IRON
Cl = CHLORIDE
HCO_3 = BICARBONATE
SO_4 = SULFATE
CO_3 = CARBONATE

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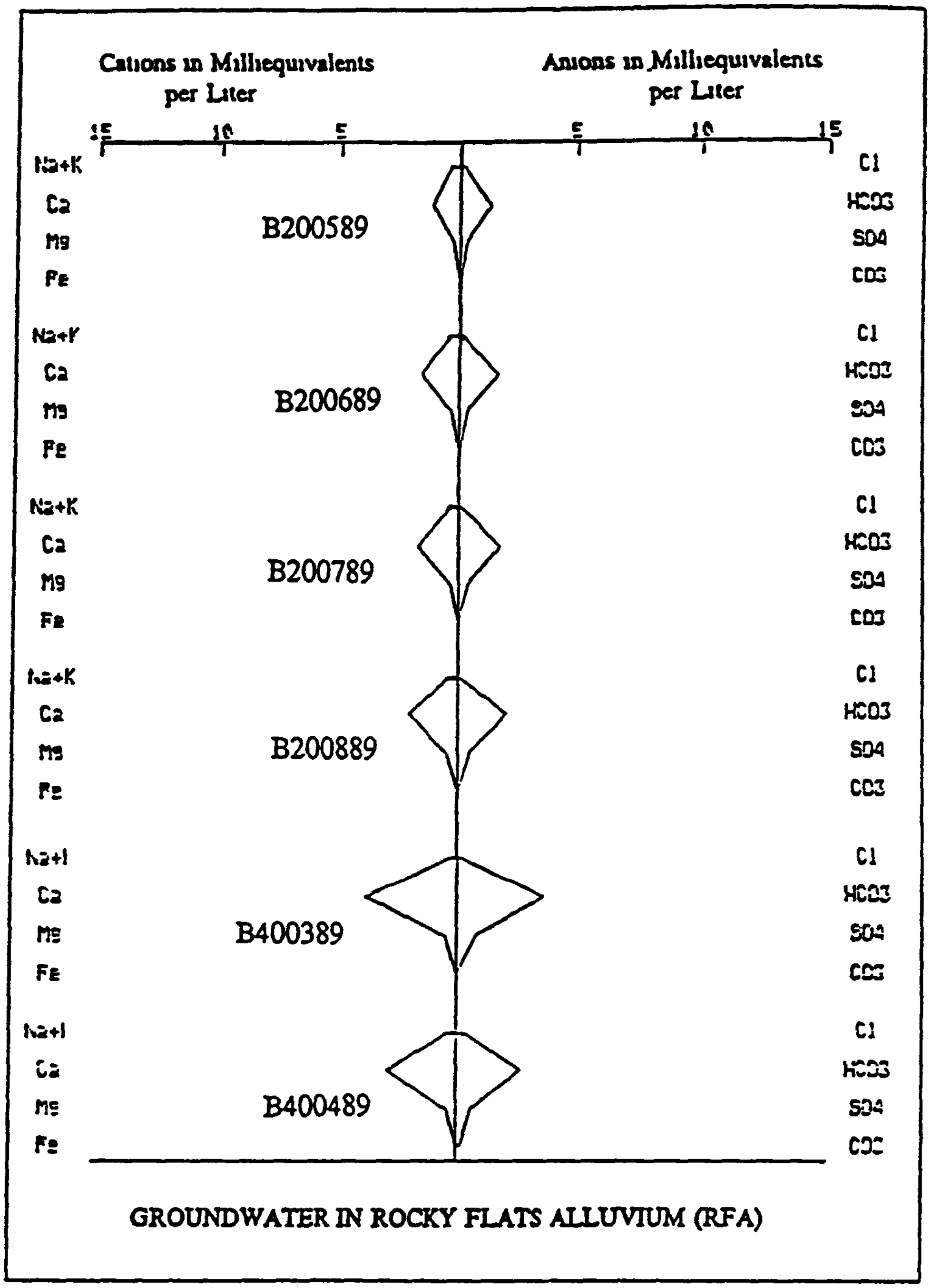
STIFF DIAGRAMS FOR BACKGROUND MONITORING WELLS SCREENED IN VALLEY-FILL ALLUVIUM

FIGURE 3 6-4

APRIL 1995

OU6RI284 1=1



EXPLANATION

Na = SODIUM
K = POTASSIUM
Ca = CALCIUM
Mg = MAGNESIUM
Fe = IRON
Cl = CHLORIDE
HCO_3 = BICARBONATE
SO_4 = SULFATE
CO_3 = CARBONATE

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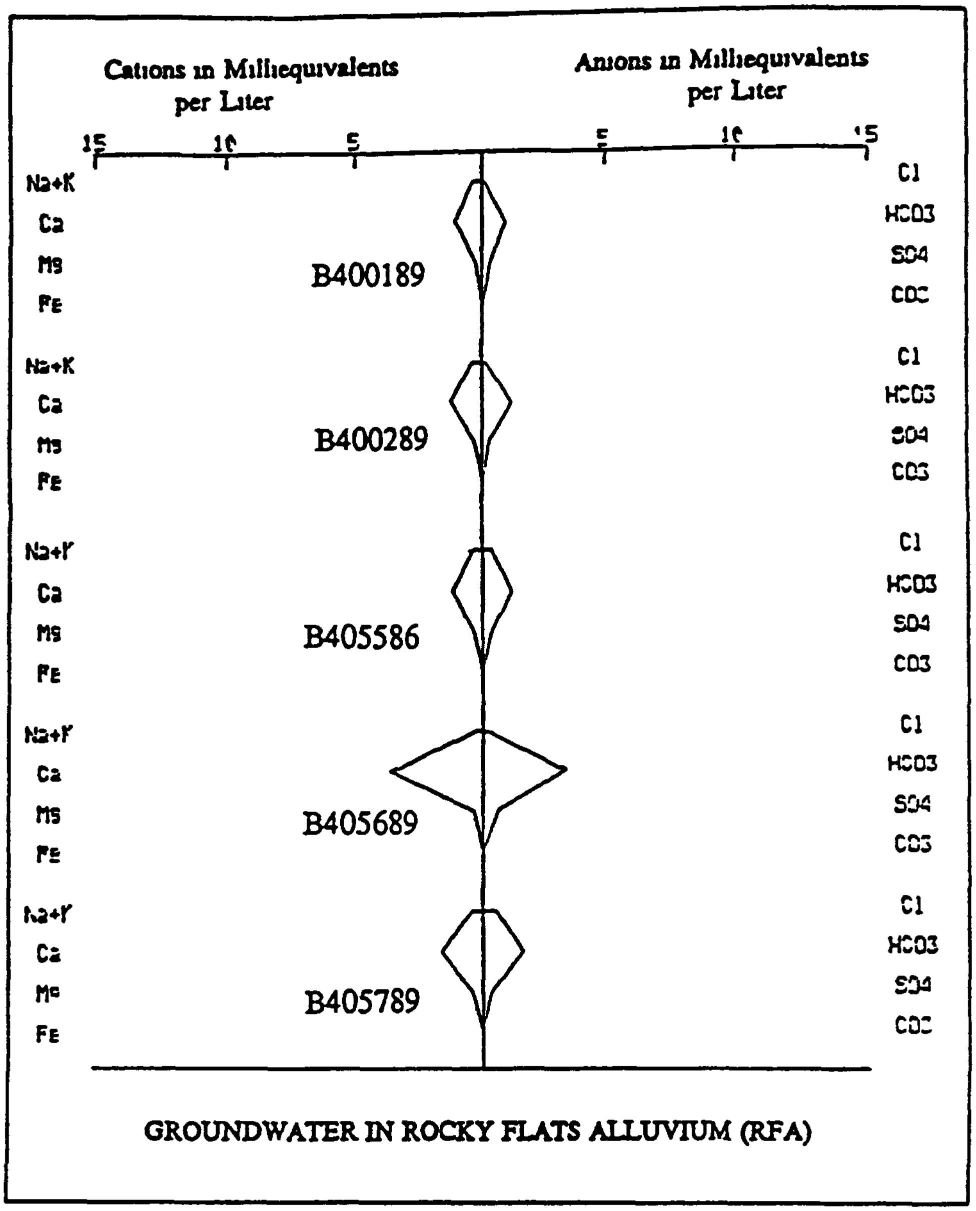
STIFF DIAGRAMS FOR BACKGROUND MONITORING WELLS SCREENED IN ROCKY FLATS ALLUVIUM
(PAGE 1 OF 2)

FIGURE 3 6-5

APRIL 1995

OU6RI285 1=1



EXPLANATION

Na = SODIUM
K = POTASSIUM
Ca = CALCIUM
Mg = MAGNESIUM
Fe = IRON
Cl = CHLORIDE
HCO_3 = BICARBONATE
SO_4 = SULFATE
CO_3 = CARBONATE

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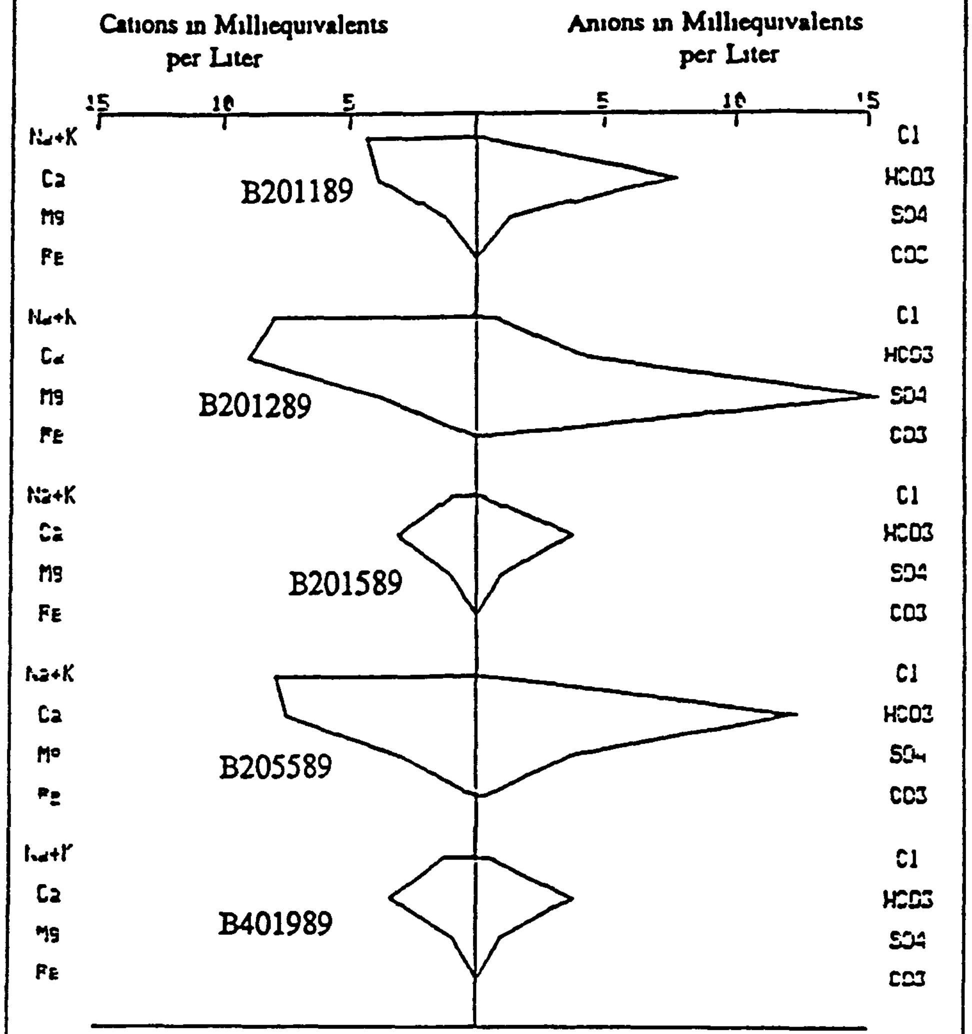
STIFF DIAGRAMS FOR BACKGROUND MONITORING WELLS SCREENED IN ROCKY FLATS ALLUVIUM
(PAGE 2 OF 2)

FIGURE 3 6-5

APRIL 1995

OU6RI286 1=1



GROUNDWATER IN COLLUVIUM (COL)

EXPLANATION

Na = SODIUM
K = POTASSIUM
Ca = CALCIUM
Mg = MAGNESIUM
Fe = IRON
Cl = CHLORIDE
HCO_3 = BICARBONATE
SO_4 = SULFATE
CO_3 = CARBONATE

SOURCE DOE 1993e

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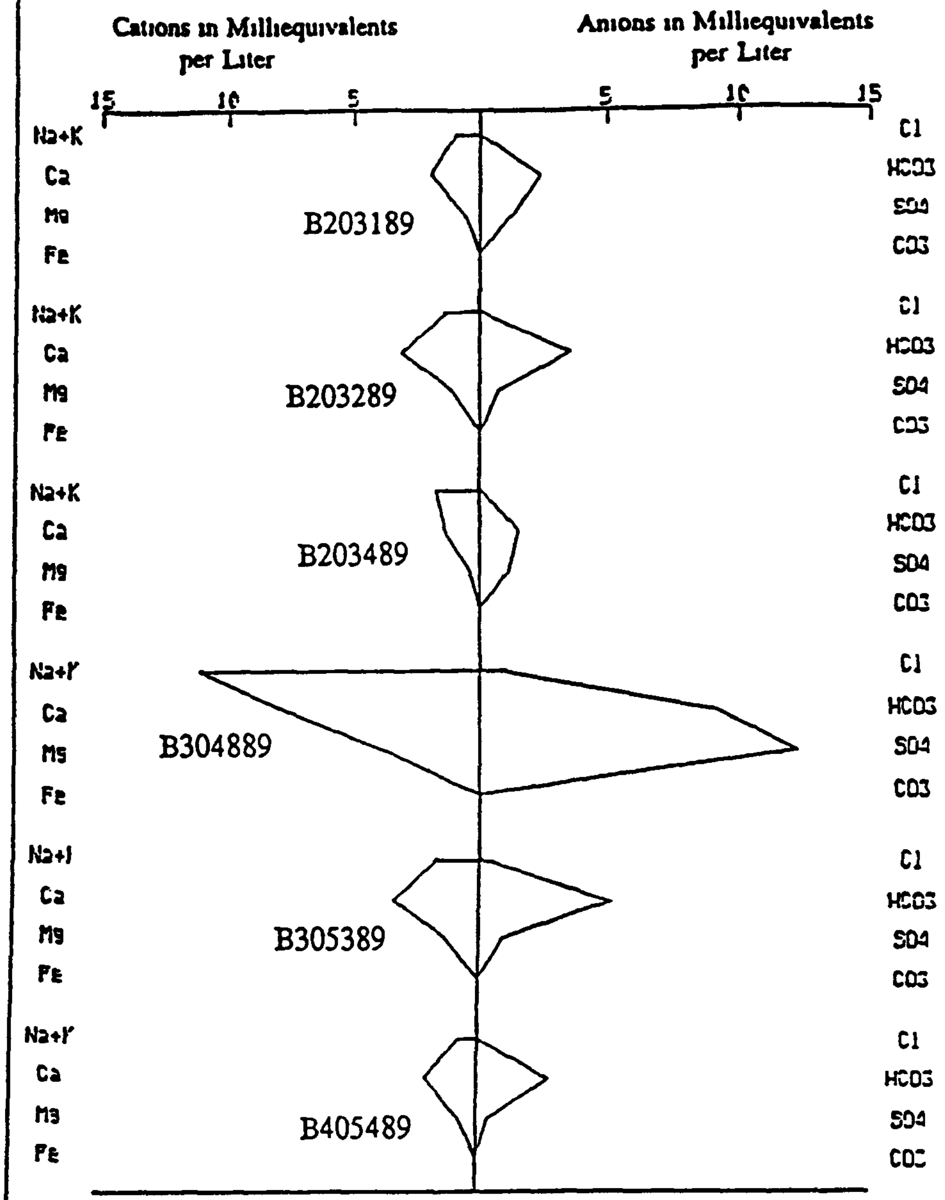
STIFF DIAGRAMS FOR BACKGROUND MONITORING WELLS SCREENED IN COLLUVIUM

FIGURE 3 6-6

APRIL 1995

OU6RI287 1=1



GROUNDWATER IN WEATHERED CLAYSTONE (WCS)

EXPLANATION

Na = SODIUM
K = POTASSIUM
Ca = CALCIUM
Mg = MAGNESIUM
Fe = IRON
Cl = CHLORIDE
HCO_3 = BICARBONATE
SO_4 = SULFATE
CO_3 = CARBONATE

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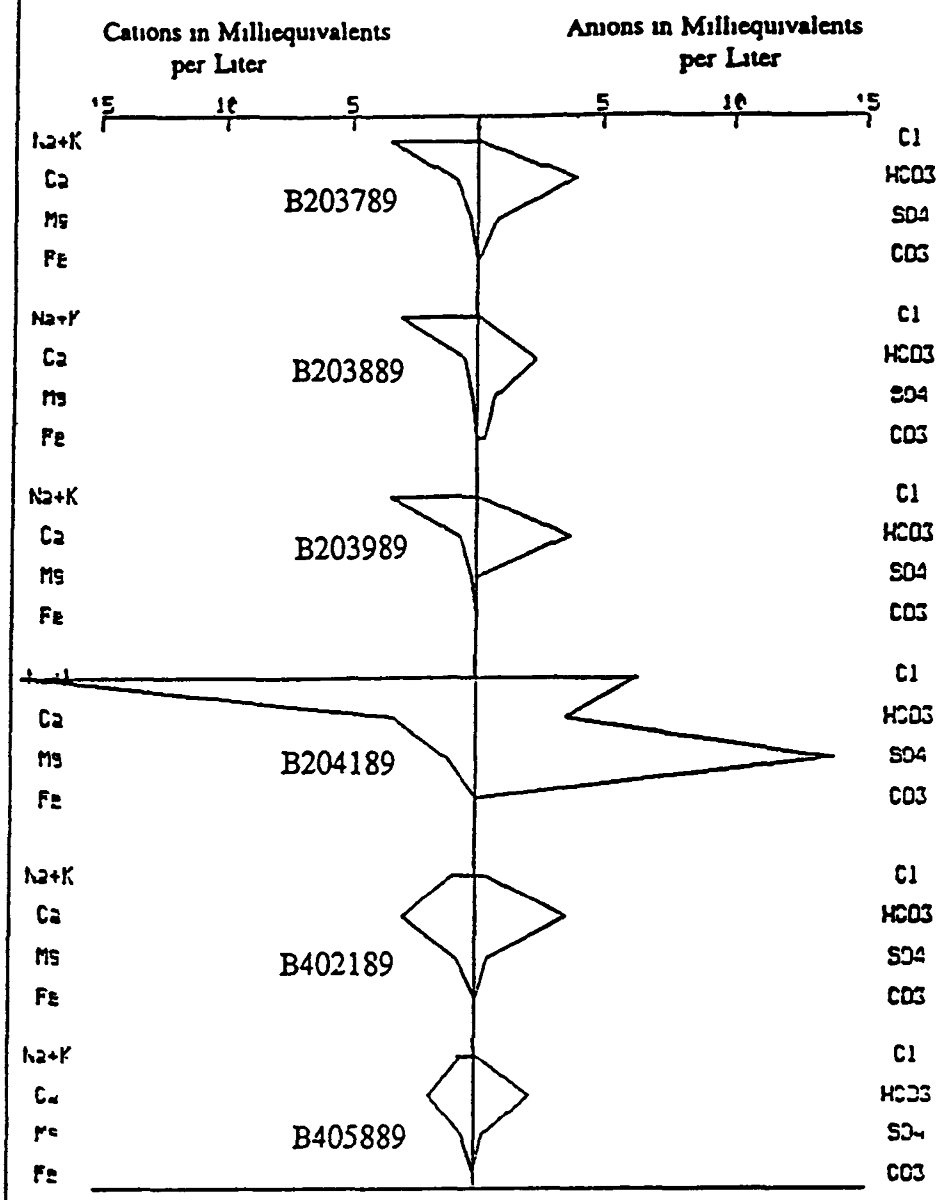
STIFF DIAGRAMS FOR BACKGROUND MONITORING WELLS SCREENED IN WEATHERED CLAYSTONE

FIGURE 3 6-7

APRIL 1995

OU6RI288 1=1



GROUNDWATER IN CRETACEOUS ARAPAHOE FORMATION (KAR)

EXPLANATION

Na = SODIUM
K = POTASSIUM
Ca = CALCIUM
Mg = MAGNESIUM
Fe = IRON
Cl = CHLORIDE
HCO_3 = BICARBONATE
SO_4 = SULFATE
CO_3 = CARBONATE

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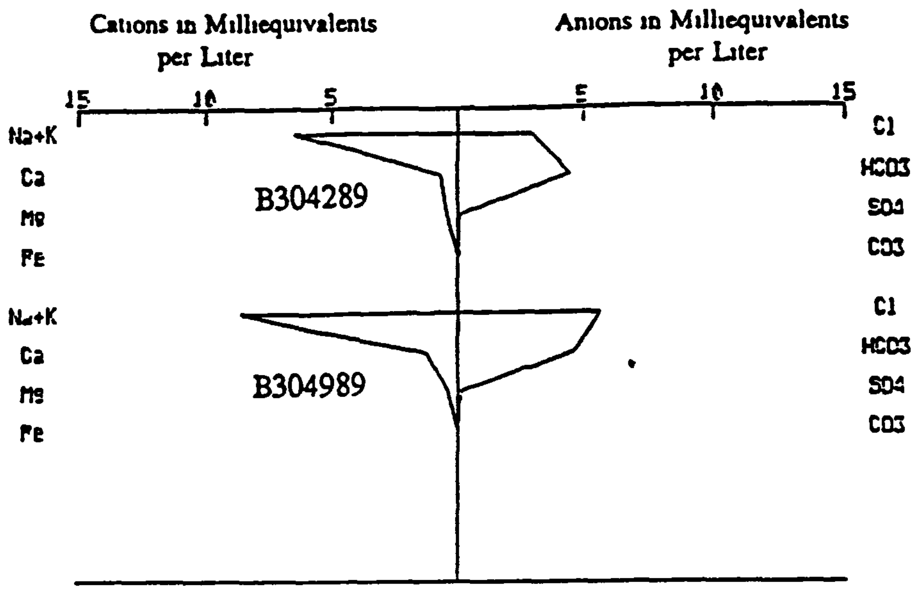
STIFF DIAGRAMS FOR BACKGROUND MONITORING WELLS SCREENED IN CRETACEOUS ARAPAHOE FORMATION (PAGE 1 OF 2)

FIGURE 3 6-8

APRIL 1995

OU6RI289 1=1



GROUNDWATER IN CRETACEOUS ARAPAHOE FORMATION (KAR)

EXPLANATION

Na = SODIUM
K = POTASSIUM
Ca = CALCIUM
Mg = MAGNESIUM
Fe = IRON
Cl = CHLORIDE
HCO_3 = BICARBONATE
SO_4 = SULFATE
CO_3 = CARBONATE

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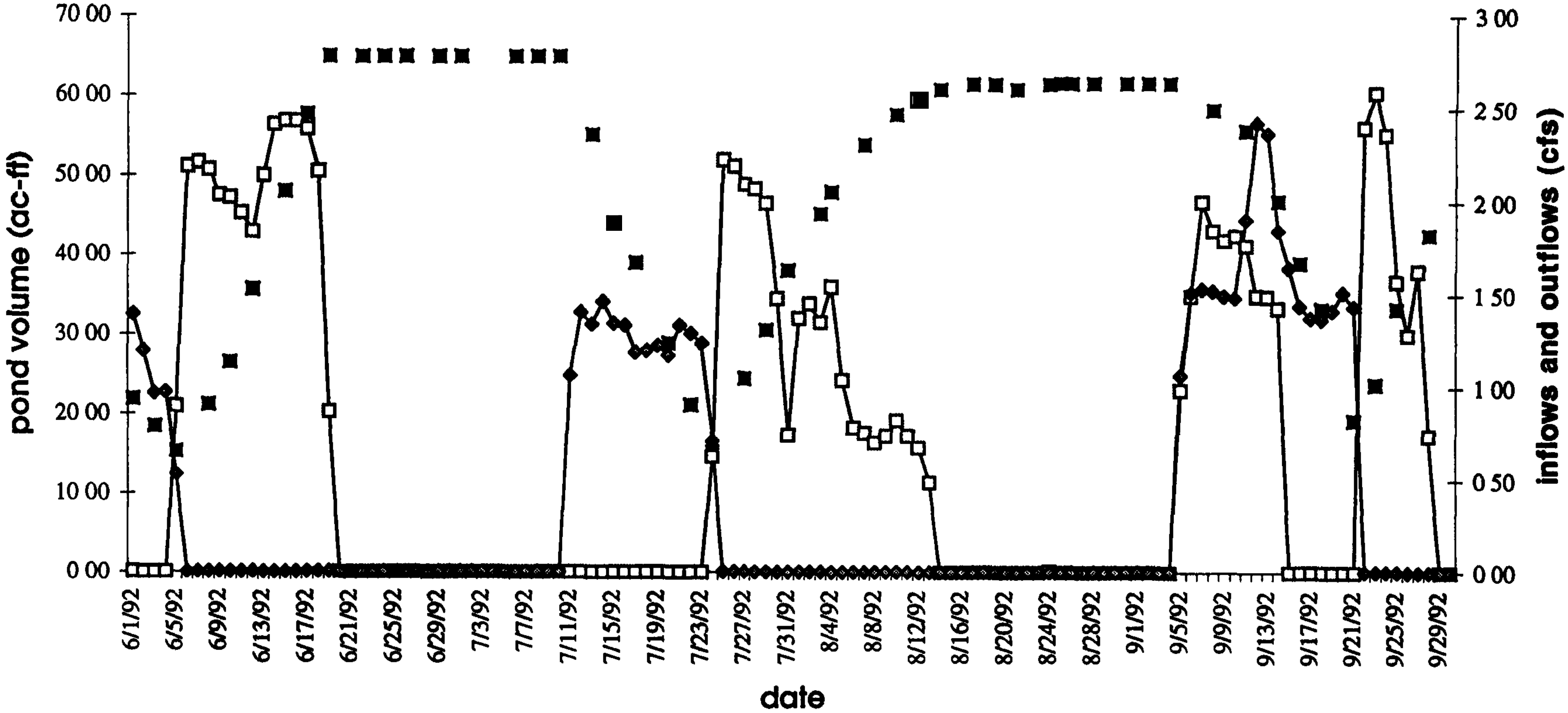
STIFF DIAGRAMS FOR BACKGROUND MONITORING WELLS SCREENED IN CRETACEOUS ARAPAHOE FORMATION (PAGE 2 OF 2)

FIGURE 3 6-8 APRIL 1995

OU6RI290 1=1



DRAFT

EXPLANATION

- POND A–4 VOLUME
- INFLOWS FROM PONDS A–3 AND B–5
- POND A–4 OUTFLOW

AC–FT – ACRE–FEET
CFS – CUBIC FEET PER SECOND

FROM EG&G STAGE AND GAUGING DATA

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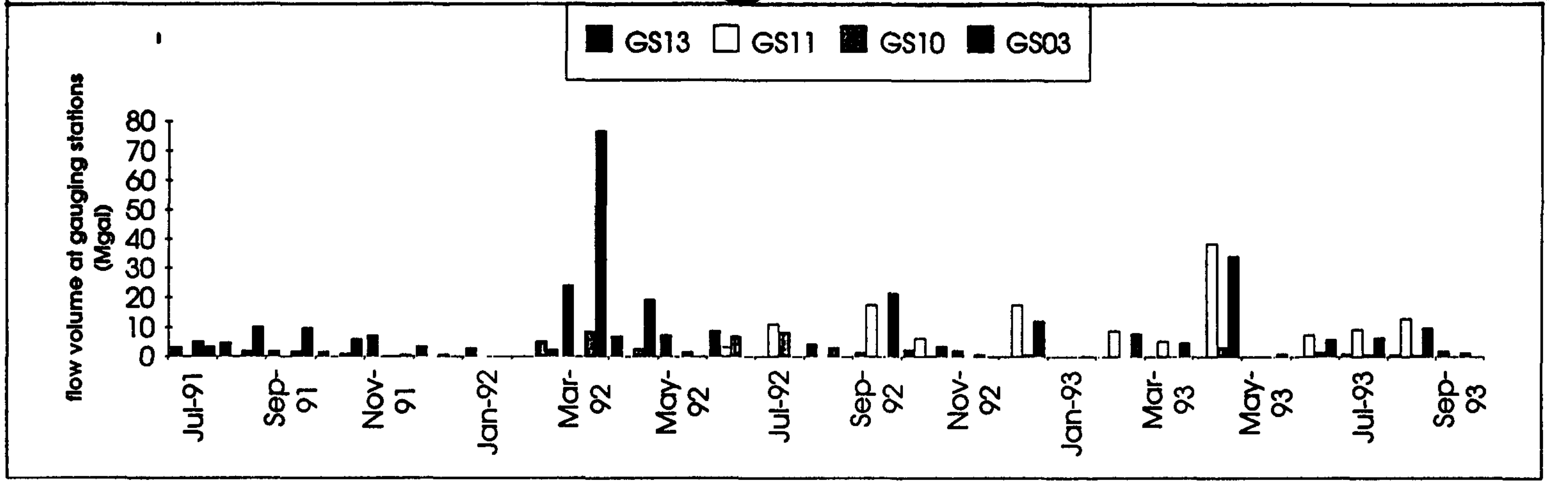
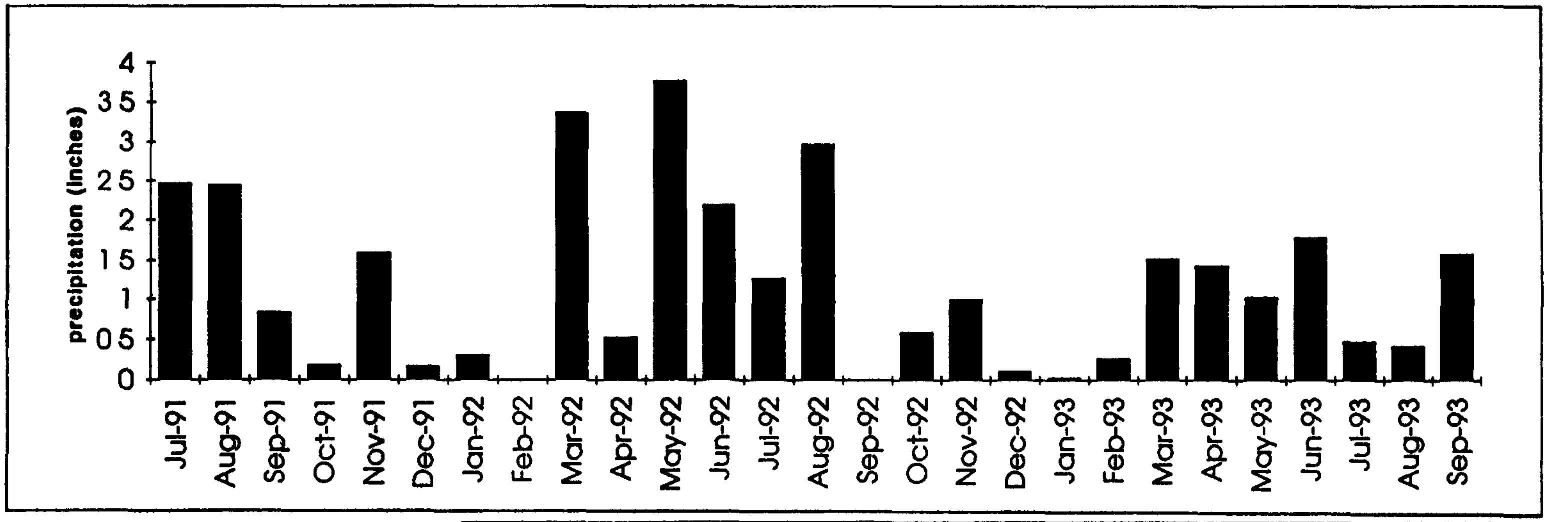
VOLUMES, INFLOWS, AND OUTFLOWS FOR POND A–4

FIGURE 3 7–2

JUNE 1995

OU6RI291 1=1





DRAFT

EXPLANATION

Mgal – MILLIONS OF GALLONS

GS – GAUGING STATION

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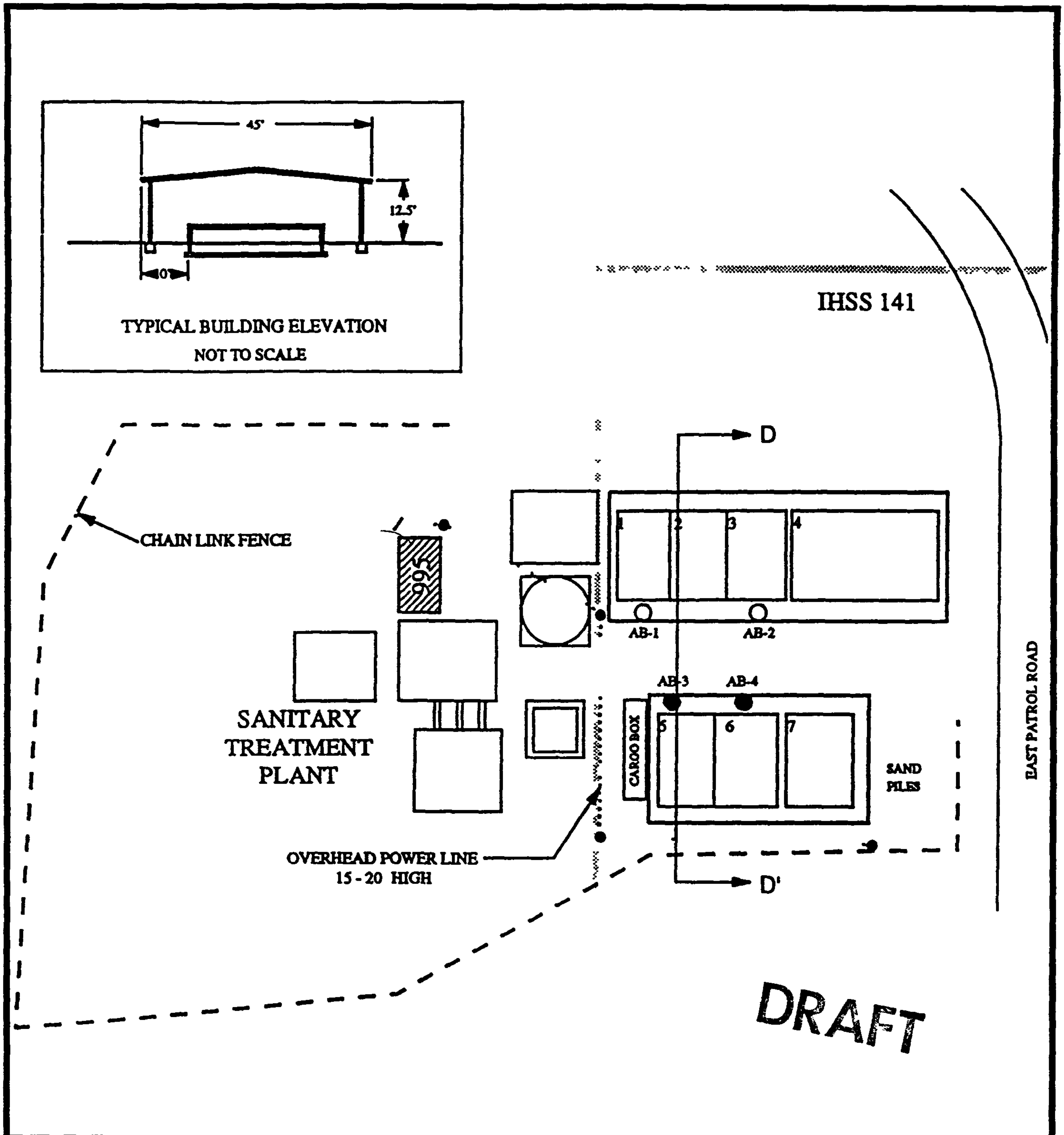
MONTHLY PRECIPITATION AND FLOWS AT OU6 GAUGING STATIONS GS03, GS10, GS11, AND GS13

FIGURE 3 7–3

JUNE 1995

OU6RI292 1-1



-N-

0 25 50

SCALE IN FEET

EXPLANATION

● SOIL SAMPLING WITH SHALLOW AND DEEP LYSIMETERS

○ SOIL SAMPLING ONLY

AB-1 BORING REFERENCE NUMBER

D / D CROSS SECTION LOCATION

IHSS BOUNDARY

FROM DOE 1993b

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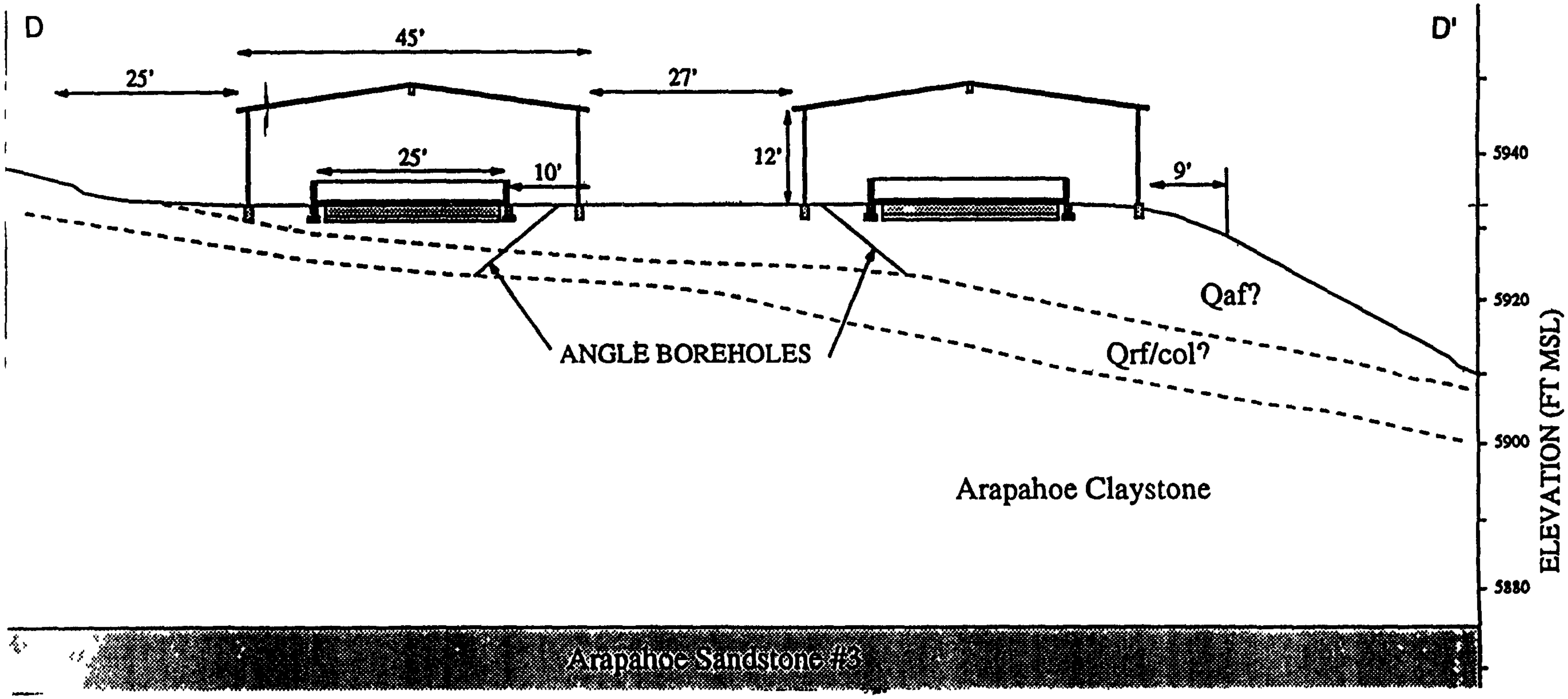
BUILDING 995 SLUDGE
DRYING BEDS LOCATION MAP

FIGURE 3 9-1

APRIL 1995

OU6RI293 1=1



SOURCE DOE 1993b

DRAFT

0 10 20
SCALE IN FEET

EXPLANATION

QUATERNARY
- Qaf – ARTIFICIAL FILL
- Qcol – COLLUVIUM
- Qrf – ROCKY FLATS ALLUVIUM

FT – FEET

MSL – MEAN SEA LEVEL

NOTE LOCATION OF CROSS SECTION D–D SHOWN ON FIGURE 3 9–1

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NORTH–SOUTH GEOLOGIC
CROSS SECTION D–D' OF BUILDING 995
SLUDGE DRYING BEDS

FIGURE 3 9–2

APRIL 1995

OU6RI294 1=1

TABLE 2 1 4
OU6 PHASE I ANALYTICAL PROGRAM

IHSS	Location	Media	TCL VOCs	TCL SVOCs	TCL Pestic des and PCBs	TAL Metals/ Additio al Metals	Gross α and β	U 233/234 235 and 238	Pu 239/240	Am 241	Cs 137	Sr 89/90	H_3	TOC	N trate/ Nitrite as N	WQPL
141	Surface samples on 25 grid	Surface soil			X	X	X	X	X	X					X	
	Well dow grad nt f n t	Groundwate	X	X		X	X	X	X	X						
		Subsurface soil	X													
142 1 9 and 142 12	Sediment samples	Sedime t	X	X	X	X	X	X	X	X	X	X	X	X	X	
	Dry sediment samples	Sediment		X	X	X	X	X	X	X	X	X	X		X	
	Water samples	Surface water	X	X		Un/F	X	Un/F	Un/F	Un/F	Un/F	Un/F	X		X	X
	Wells downgradie t of Po ds A-4 and B-5	Groundwater	X	X		Un/F	X	Un/F	Un/F	Un/F	Un/F	Un/F	X		X	X
143	Surface samples	Surface soil		X	X	X	X	X	X	X			X	X	X	
	Core samples on 20 grid	S bsurface soil	X	X	X	X	X	X	X	X			X	X	X	
	W ll downgradie t of n t	Groundwater	X	X	X	X	X	X	X	X			X	X	X	
156 2	Surface samples	Surface soil				X	X	X	X	X				X		
	Borings	Subsurface soil	X			X	X	X	X	X						
	Well within un t	Groundwater				Un/F	X	Un/F	Un/F	Un/F						X
165	Surfac samples from transect locatio s	Surface soil			X	X	X	X	X	X				X		
	Borings to confirm soil gas	Subsurface soil	X	X			X	X	X	X						
	Borings transecting plumes grabs from 2 intervals 6' composites	S bsurface soil	X	X		X	X	X	X	X						
	Wells within the site	Groundwater	X	X	X	X	X									
.1 3	Borings along each tre ch grabs from 2 intervals 6' composites	Subsurface soil	X			X	X	X	X	X						
	Well downgradient of the trenches	Groundwater	X	X	X	X	X									
167 1 and 167.3	Surface and core samples on 100' grid	Surface and Subsurface soil	X			X X	X X	X X	X X	X X				X X		
	Wells downgradient of units	Groundwater	X		X	X	X	Un/F	Un/F	X			X		X	
216 1	Surface and core samples	Surface and Subsurface soil	X			X	X	X	X	X			X	X		

(4047-910-0025-521)(R7-T214)(4/5/95 10:29 am)(2)

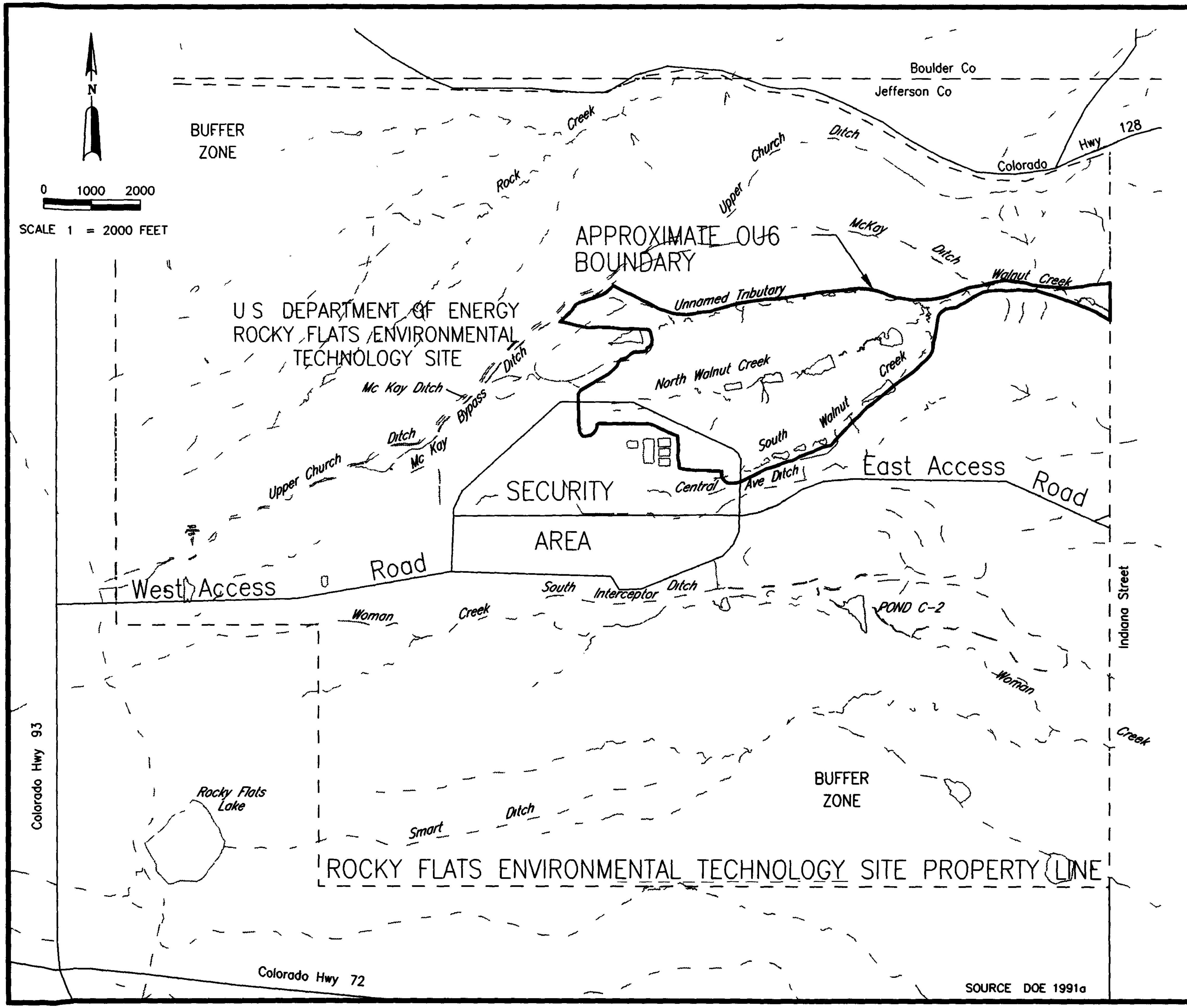
TABLE 2 1-4
OU 6 PHASE I ANALYTICAL PROGRAM

IHSS	Location	Med	GFAA M tal	VOCs	TCL SVOCs	TAL Metals/ Additional Metals	TCL Pestic des and PCBs	Gross ∝ and β	U 233/234 235 238	Pu 239/240	Am 241	Cs 137	S 89/90	H_3	TOC	N trate and N trate as N	NH_4 as NH_3	T x ty	Hard ss	WQPL
N/A	Stream Base Flow Sampling	Surface Wate	X	X	X	Un/F		X	Un/F	Un/F	Un/F	Un/F	Un/F	X	X	X	X	A/M	X	X
N/A	Stream Storm Event Sampling	Surface Water	X	X	X	Un/F		X	X	Un/F	Un/F	Un/F	Un/F	X	X	X	X	A/M	X	X
N/A	Stream	Sediments			X	Un/F	X	X	X	X	X	X	X	X	X	X				

Explanations

Six randomly chosen surface soil samples were analyzed fo TCL pesticides/PCBs

α = Alpha
β = Beta
A = Acute
Am = Americium
Be = Beryllium
Cr = Chromium
Cs = Cesium
F = Filtered Water Sample
H = Tritium
M = Micro
N = Nitrogen
Pu = Plutonium
Sr = Strontium
SVOCs = Semivolatile Organic Compounds
TAL = Target Analyte List
TCL = Target Compound List
TDS = Total Dissolved Solids
TOC = Total Organic Carbon
U = Uranium
Un = Unfiltered Water Sample
VOCs = Volatile Organic Compounds
GF[illegible]A = Graphite Furnace Atomic Absorption
[illegible]L = Water Quality Parameters List
[illegible] = Ammonium ion as NH_3
PCBs = Polychlorinated Biphenyls



EXPLANATION

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE (RFETS) PROPERTY LINE

OPERABLE UNIT NO 6 (OU6) BOUNDARY

DRAINAGES

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Golden Colorado

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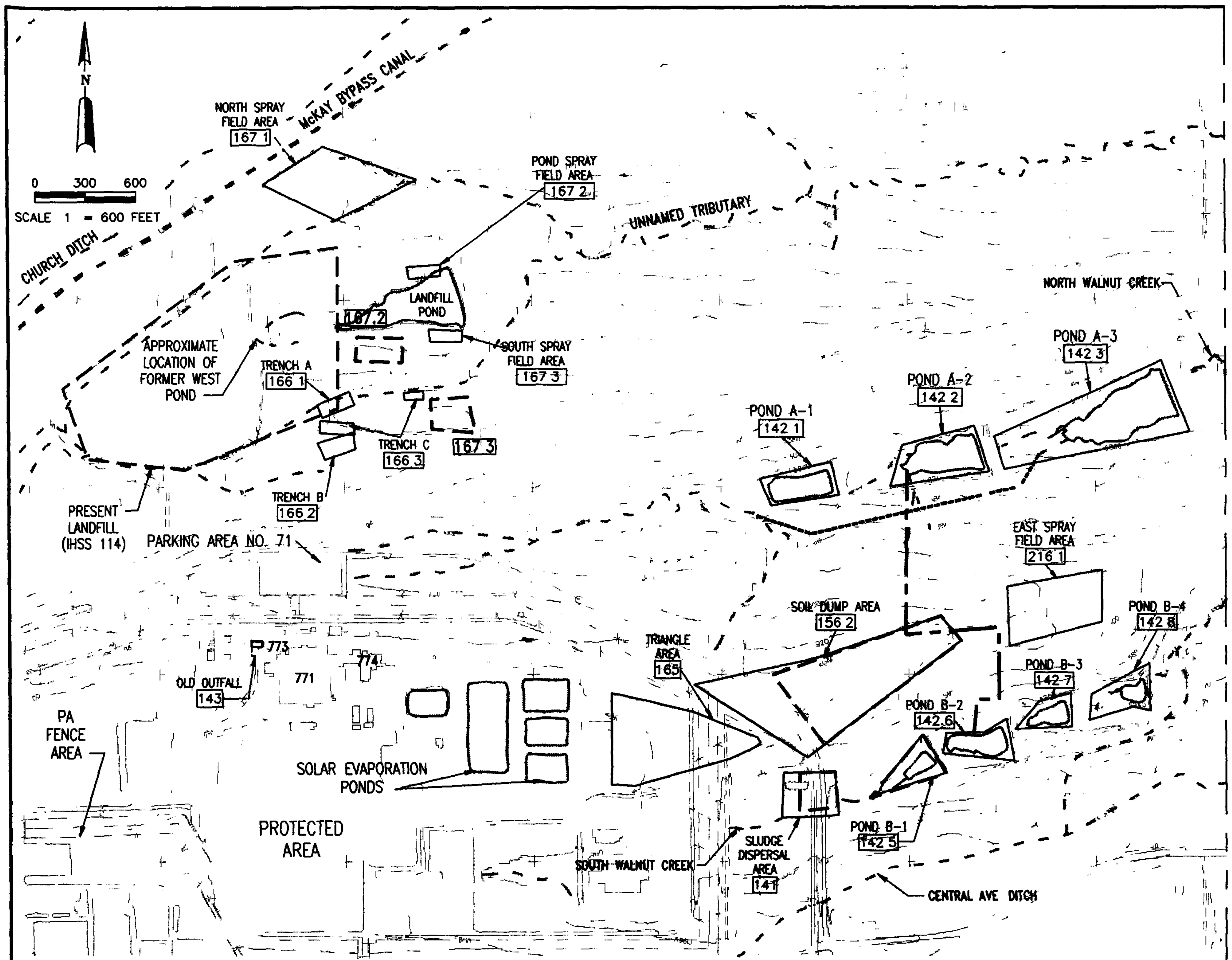
RFETS AND OU6 BOUNDARIES

FIGURE 1 3-2 REV APRIL 1995

1 14 OU6RI039 1=2000



SOURCE. DOE 1992a

EXPLANATION

- INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) IN OPERABLE UNIT 6 (OU-6)
- 142 3 — IHSS REFERENCE NUMBER
- 156.2 — OU6 HISTORICAL IHSS BOUNDARY (DOE 1987)
- PROTECTED AREA (PA) FENCE
- DIRT ROAD
- INTERMITTENT STREAM
- A-1/A-2 BYPASS (UNDERGROUND PIPELINE)
- UNDERGROUND PIPELINE FROM POND B-2 TO POND A-2

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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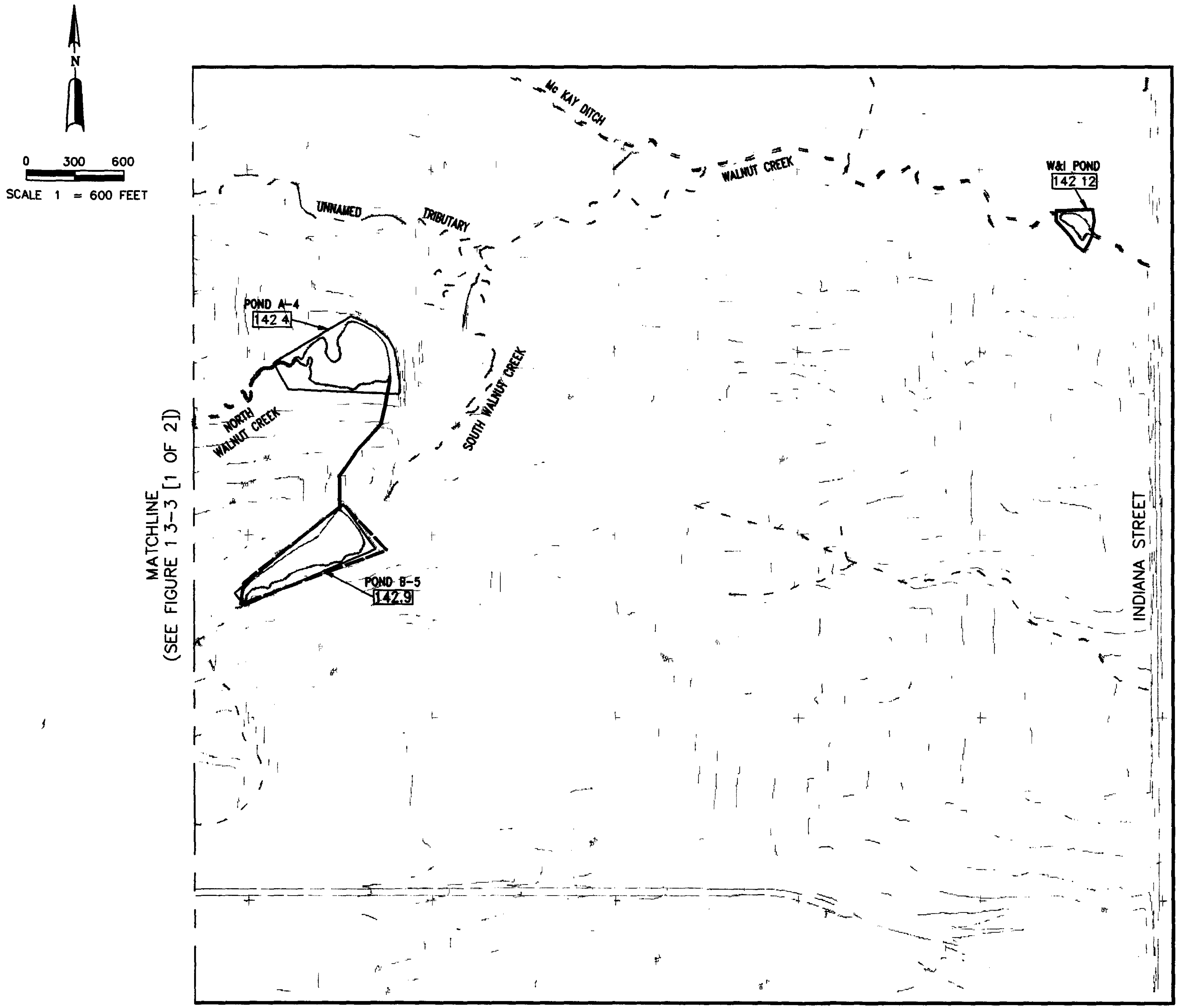
LOCATION AND IDENTIFICATION OF OU6 IHSSs AND DIVERSION STRUCTURES ALONG NORTH & SOUTH WALNUT CREEKS (PAGE 1 OF 2)

FIGURE 1 3-3

REV APRIL 1995

OU6RI243 1 600



SOURCE. DOE 1992a

EXPLANATION

- INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) IN OPERABLE UNIT 6 (OU-6)
- 142 12 — IHSS REFERENCE NUMBER
- OU6 HISTORICAL IHSS BOUNDARY (DOE 1987) — 142 9
- DIRT ROAD
- INTERMITTENT STREAM
- TRANSFER LINE FROM POND B-5 TO POND A-4

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden Colorado

OPERABLE UNIT NO 6
PHASE I RFI/RI REPORT

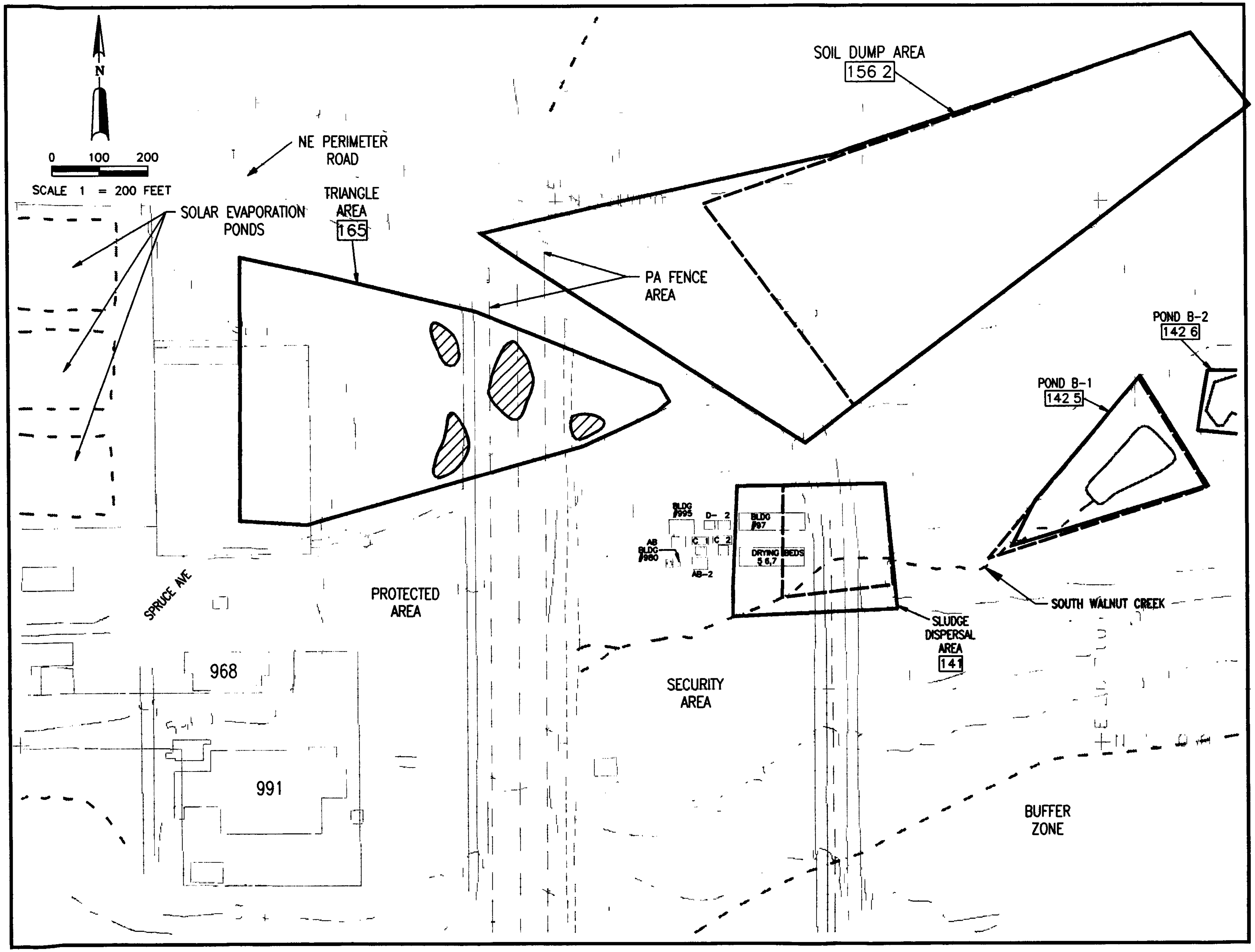
LOCATION AND IDENTIFICATION OF OU6 IHSSs AND DIVERSION STRUCTURES ALONG NORTH & SOUTH WALNUT CREEKS (PAGE 2 OF 2)

FIGURE 1 3-3

REV ARPIL 1995

14

OU6R1244 1=600



EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) IN OPERABLE UNIT 6 (OU-6)

142 5 IHSS REFERENCE NUMBER

141 OU-6 HISTORICAL IHSS BOUNDARY (DOE 1987)

DIRT ROAD

INTERMITTENT STREAM

968 ROCKY FLATS BLDG NO

SOIL EXCAVATIONS IN 1979 (RADIOMETRIC SOIL SURVEY CONTAINING ELEVATED LEVELS)

PROTECTED AREA (PA) FENCE

CONCERTINA WIRE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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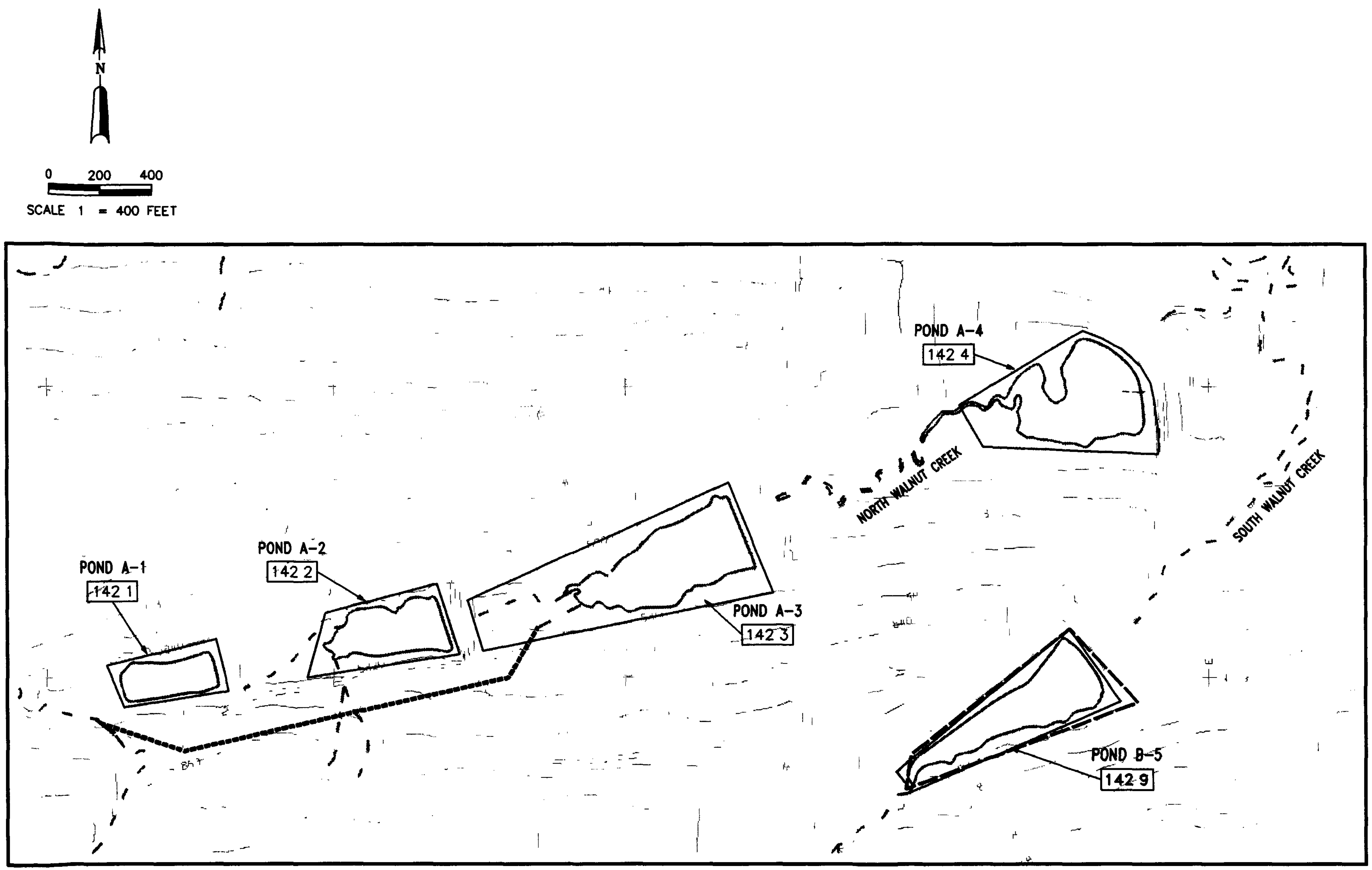
SLUDGE DISPERSAL AREA (IHSS 141)
SOIL DUMP AREA (IHSS 156 2)
AND TRIANGLE AREA (IHSS 165)

FIGURE 1 3-4

REV ARRIL 1995

OU6RI245 1 200



SOURCE. DOE 1992a

EXPLANATION

- INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) IN OPERABLE UNIT 6 (OU-6)
- 142 4 — IHSS REFERENCE NUMBER
- 142.9 — OU-6 HISTORICAL IHSS BOUNDARY (DOE 1987)
- INTERMITTENT STREAM
- DIRT ROAD
- A-1/A-2 BYPASS (UNDERGROUND PIPE)

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN H R R (DOE 1992b)

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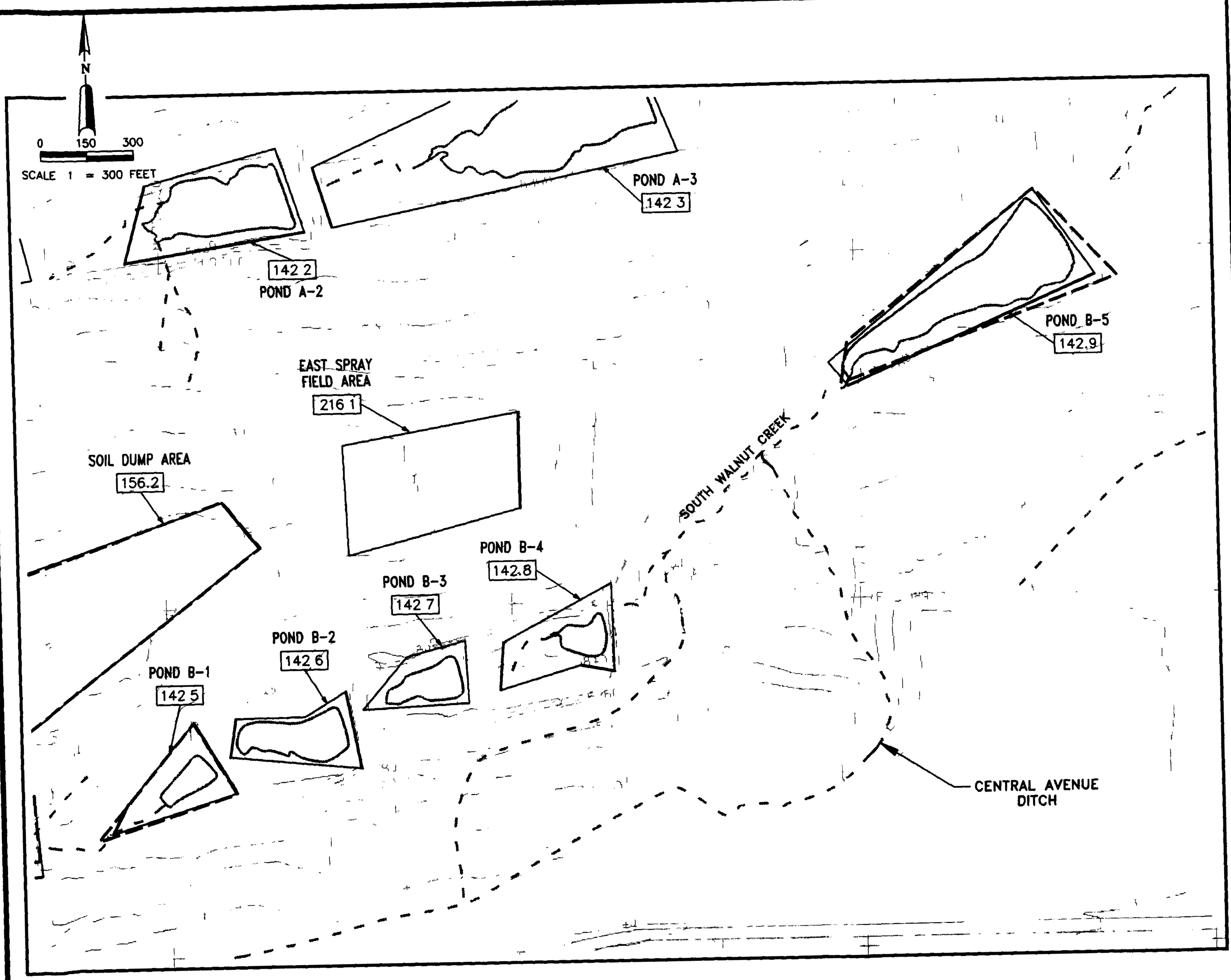
A-SERIES PONDS
A-1 THROUGH A-4
(IHSSs 142 1-142 4)

FIGURE 1 3-5

REV APRIL 1995

OU6RI246 1=400



SOURCE. DOE 1992a

EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) IN OPERABLE UNIT 6 (OU-6)

142 9 IHSS REFERENCE NUMBER

216.1 OU-6 HISTORICAL IHSS BOUNDARY (DOE 1987)

INTERMITTENT STREAM

DIRT ROAD

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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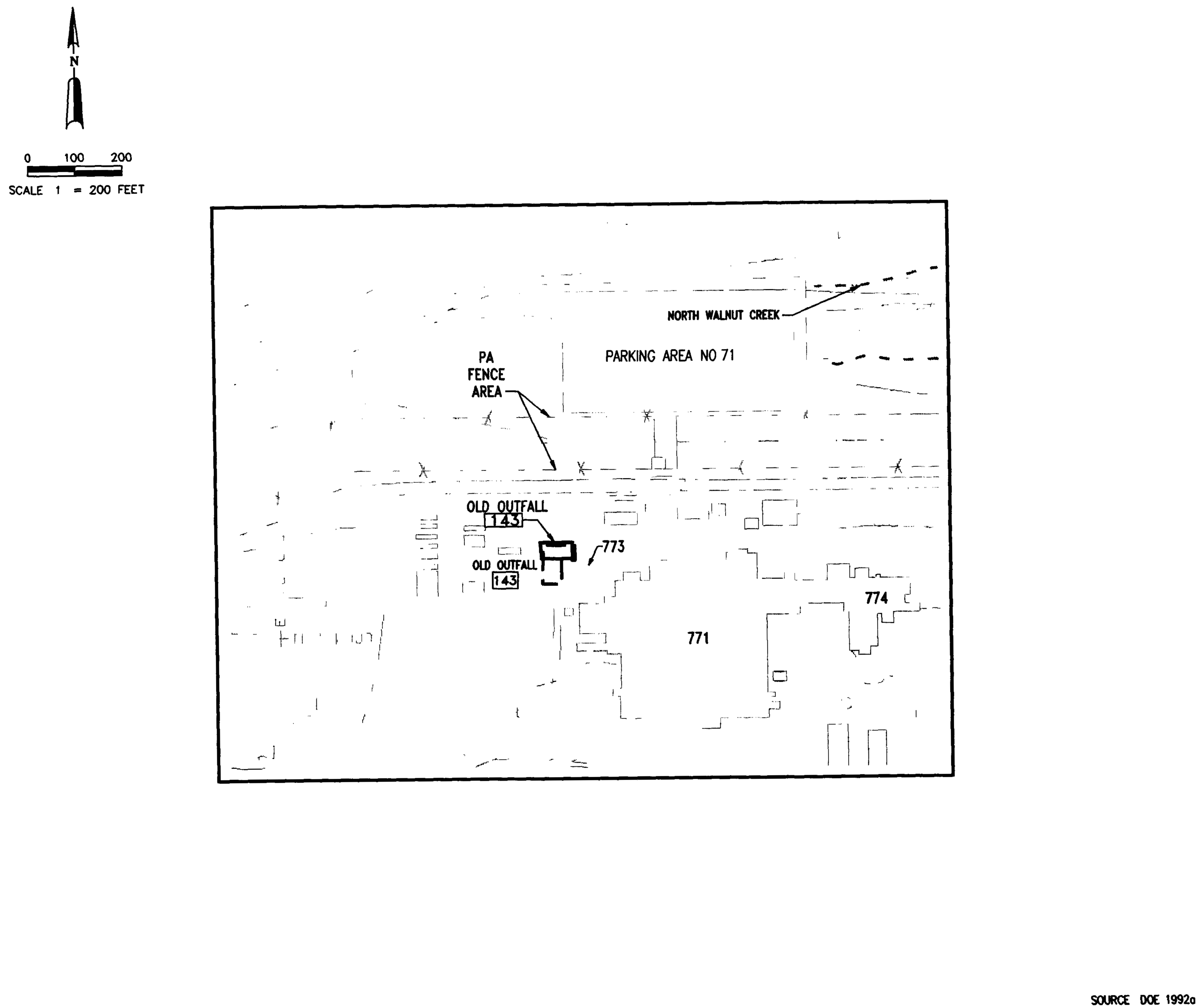
B-SERIES PONDS
B-1 THROUGH B-5
(IHSSs 142 5 - 142 9)
AND EAST SPRAY FIELD AREA
(IHSS 216 1)

FIGURE 1 3-6

REV APRIL 1995

OU6RI247 1=300



EXPLANATION

- INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) IN OPERABLE UNIT 6 (OU-6)
- 143 IHSS REFERENCE NUMBER
- 143 OU-6 HISTORICAL IHSS BOUNDARY (DOE 1987)
- INTERMITTENT STREAM
- DIRT ROAD
- 773 ROCKY FLATS BLDG NO
- PROTECTED AREA (PA) FENCE
- CONCERTINA WIRE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Rocky Flats Environmental Technology Site
Golden Colorado

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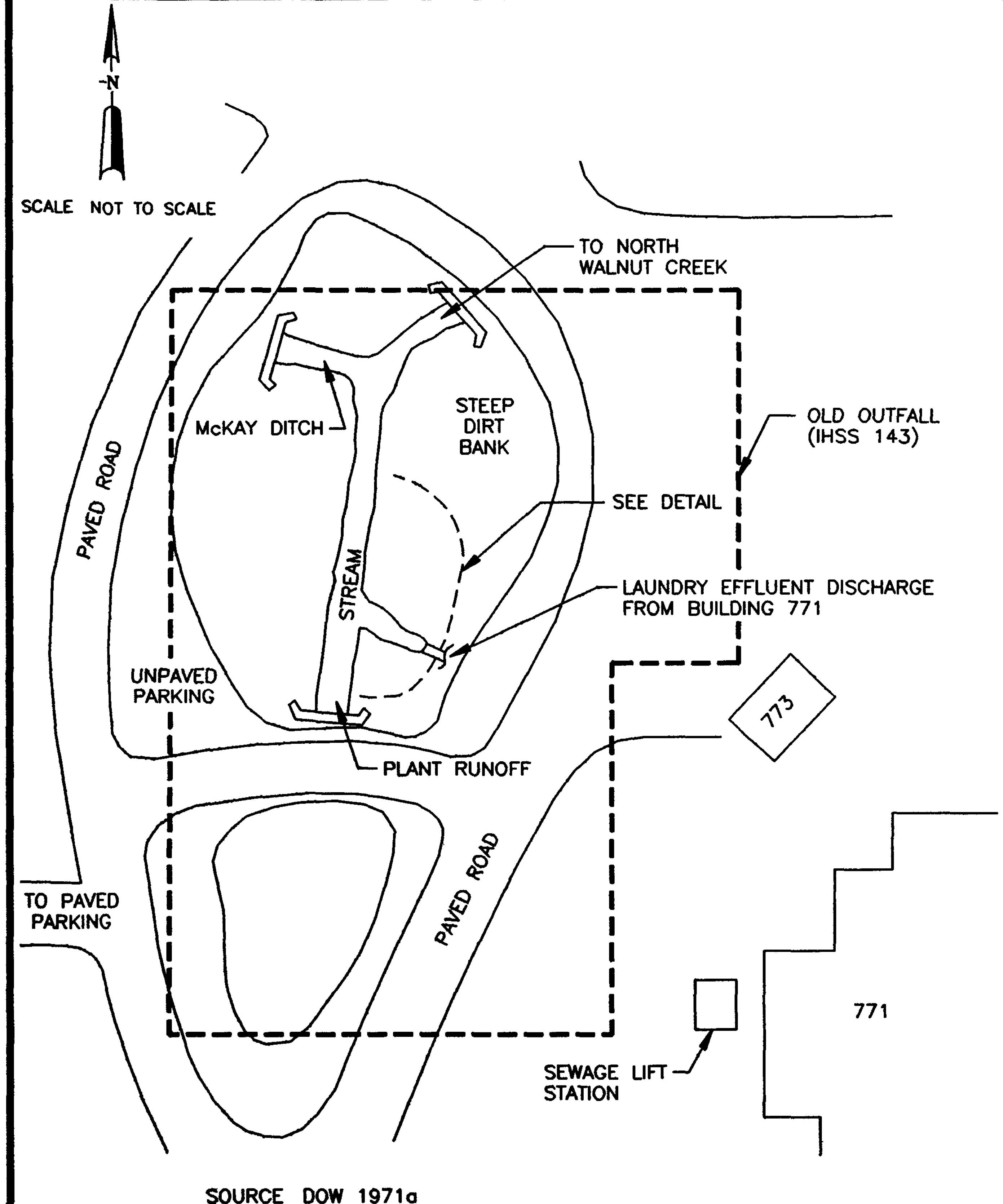
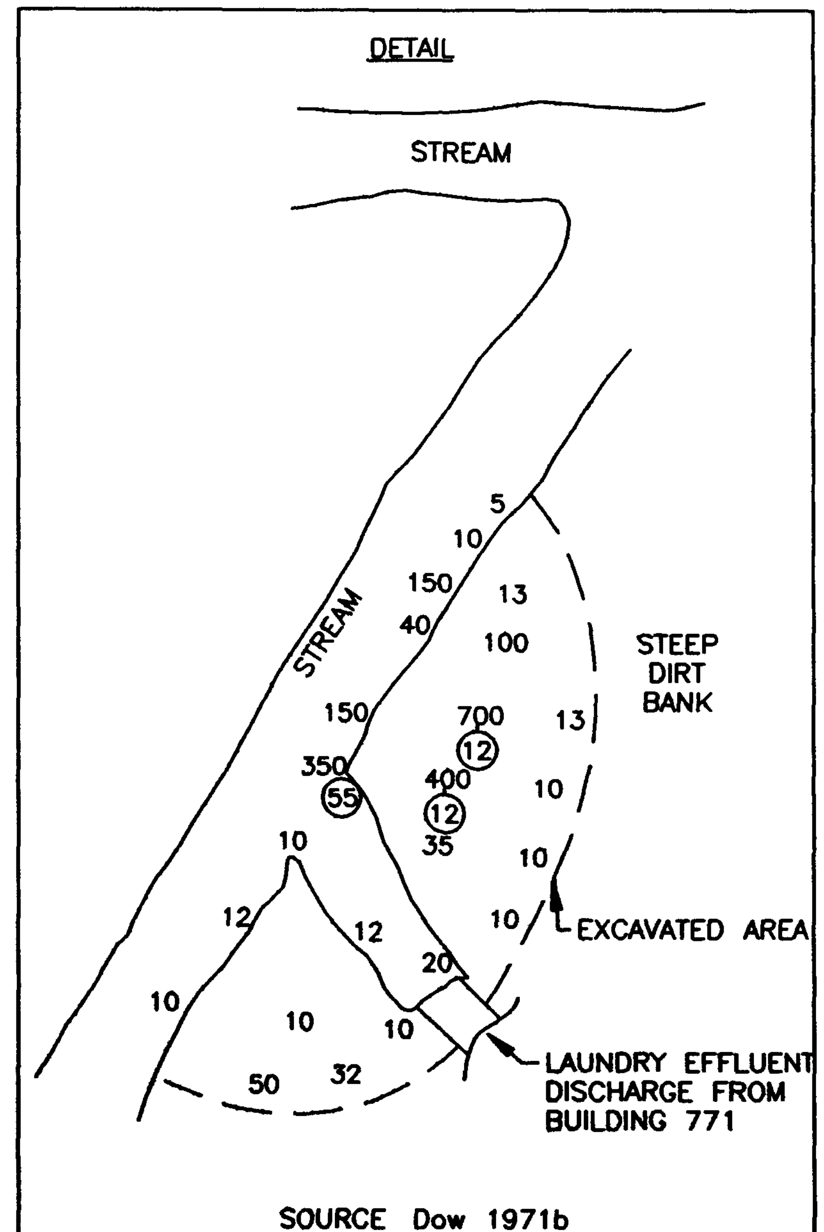
OLD OUTFALL AREA (IHSS 143)

FIGURE 1 3-7

REV APRIL 1995

1 4 OU6RI248 1=200





EXPLANATION

12 PLUTONIUM CONCENTRATIONS OF SOIL SAMPLE IN DISINTEGRATIONS PER MINUTE PER GRAM (d/m/gm)

(12) PLUTONIUM CONCENTRATIONS OF RESAMPLED SOIL SAMPLE IN d/m/gm AFTER FURTHER EXCAVATION

773 ROCKY FLATS BUILDING NO

OU6 HISTORICAL IHSS BOUNDARY

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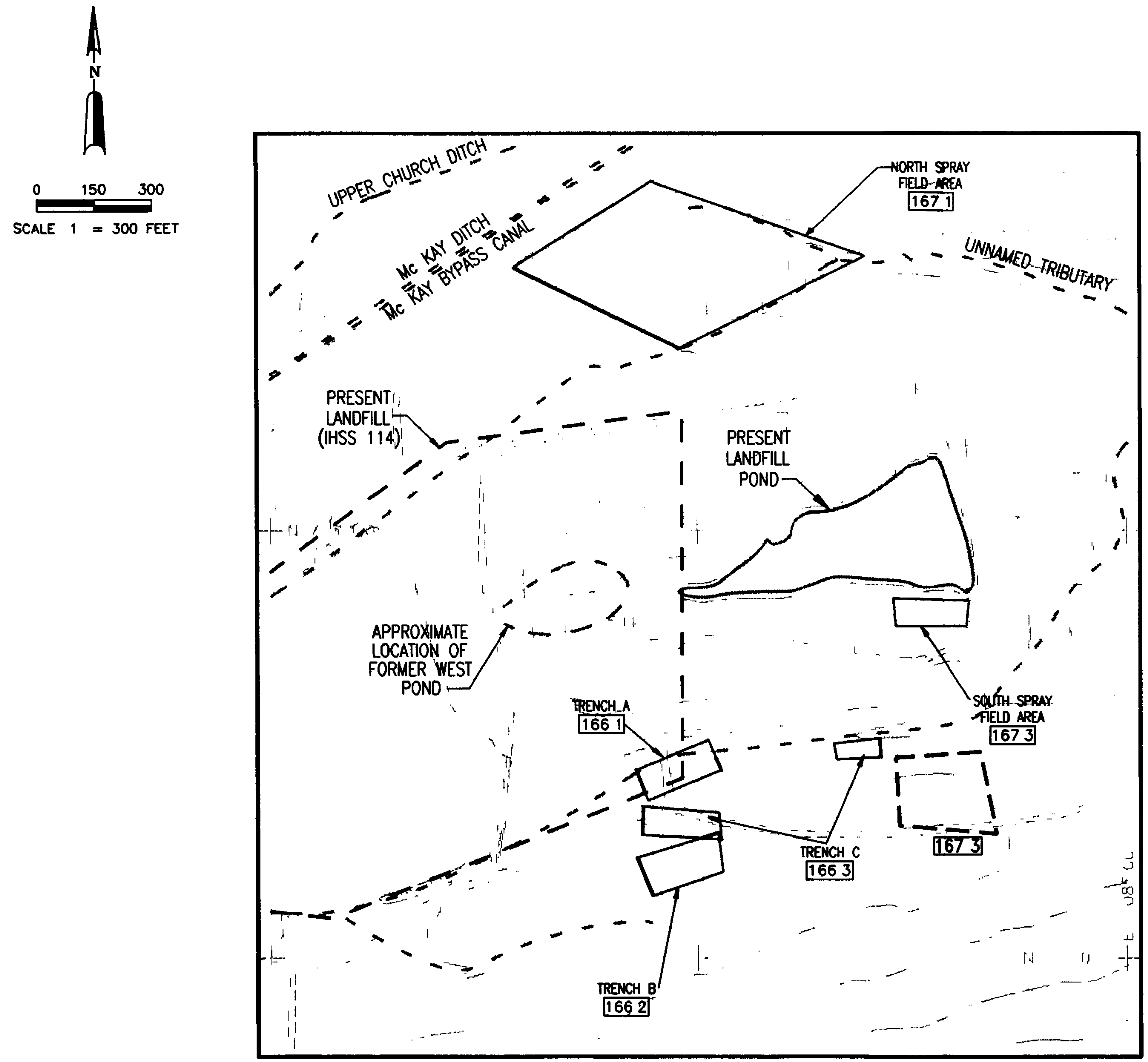
PHASE I RFI/RI REPORT

OLD OUTFALL AREA (IHSS 143)
LOCATION OF CULVERTS AND OUTFALL CATCHMENT BASIN IN FEBRUARY 1971, AND SOIL SAMPLE RESULTS FROM SOIL REMOVAL ACTIVITIES CONDUCTED BETWEEN FEBRUARY AND AUGUST 1971

FIGURE 1 3-8 REV APRIL 1995

3/17/95 OU6R1046 1=1



SOURCE. DOE 1992a

EXPLANATION

	INDIVIDUAL HAZARDOUS SUBSTANCE SITE* (IHSS) IN OPERABLE UNIT 6 (OU 6)
167 1	IHSS REFERENCE NUMBER
167 3	OU-6 HISTORICAL IHSS BOUNDARY (DOE 1987)
	INTERMITTENT STREAM
	DIRT ROAD
	LANDFILL BOUNDARY

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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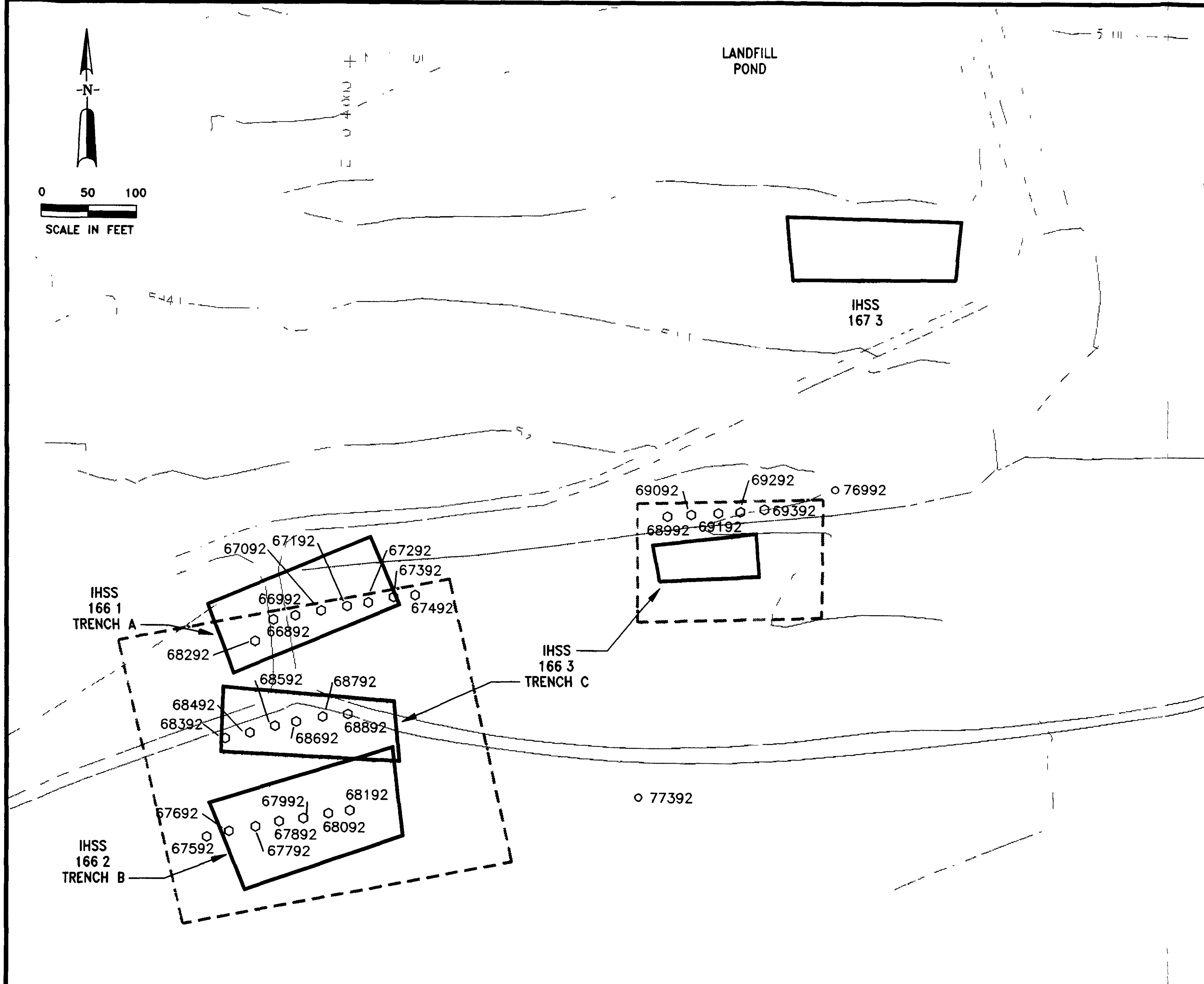
PHASE I RFI/RI REPORT

TRENCHES A B AND C
(IHSSs 166 1 – 166 3)
NORTH SPRAY FIELD
AND SOUTH SPRAY FIELD AREAS
(IHSSs 167 1 AND 167 3)

FIGURE 1 3-9 REV APRIL 1995

OU6RI249 1 300



EXPLANATION

IHSS BOUNDARIES

ELECTROMAGNETIC GEOPHYSICAL SURVEY GRID BOUNDARY

SOIL BORING

PHASE I MONITORING WELL (ALLUVIAL)

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN H R R (DOE 1992b)

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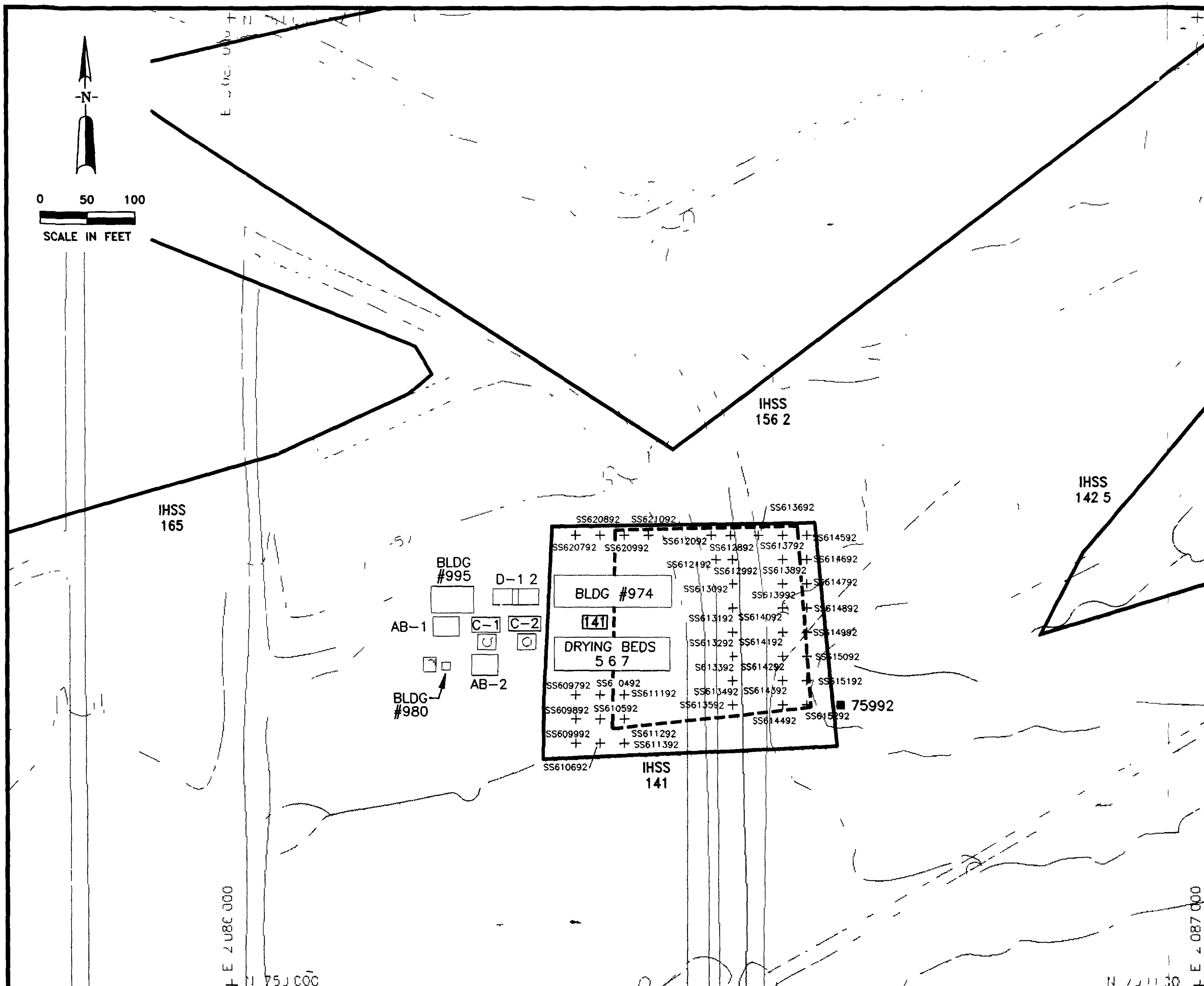
ELECTROMAGNETIC SURVEY
(IHSSs 166 1–166 3)

FIGURE 2 1–1

APRIL 1995

3/20/95

OU6R0254 1 100



EXPLANATION

IHSS BOUNDARIES

141 HISTORICAL IHSS BOUNDARY (DOE 1987)

+ SS61369 SURFACE SOIL SAMPLING SITE

■ 75992 MONITORING WELL (COLLUVIAL)

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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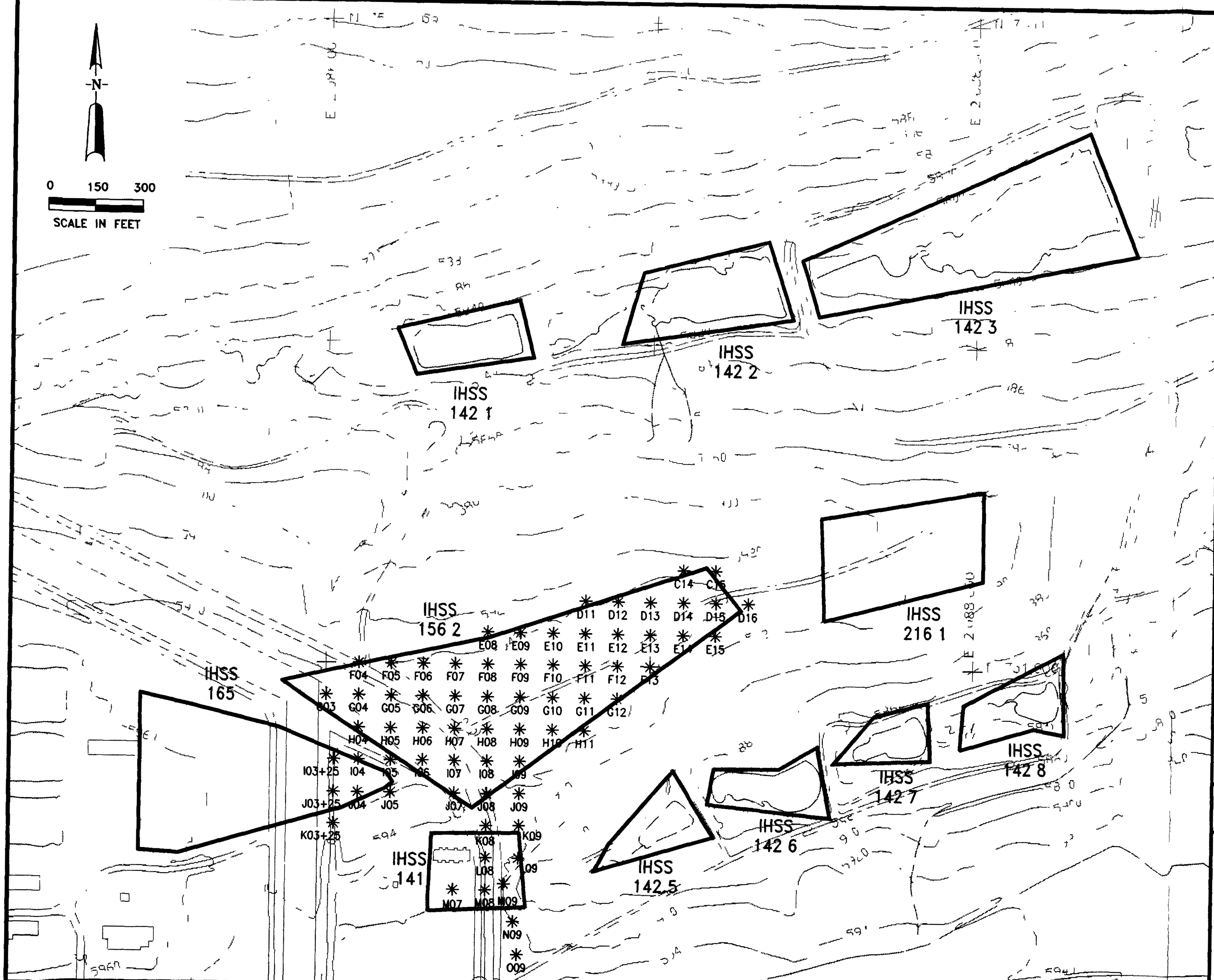
SURFACE SOIL SAMPLE AND MONITORING WELL LOCATIONS (IHSS 141)

FIGURE 2 2-1

APRIL 1995

/6 95

OU6RI026 1=100



EXPLANATION

* GROUND-BASED GERMANIUM RADIATION SURVEY POINTS

IHSS BOUNDARIES

FROM EG&G JULY 9 1993

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Rocky Flats Environmental Technology Site
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PHASE I RFI/RI REPORT

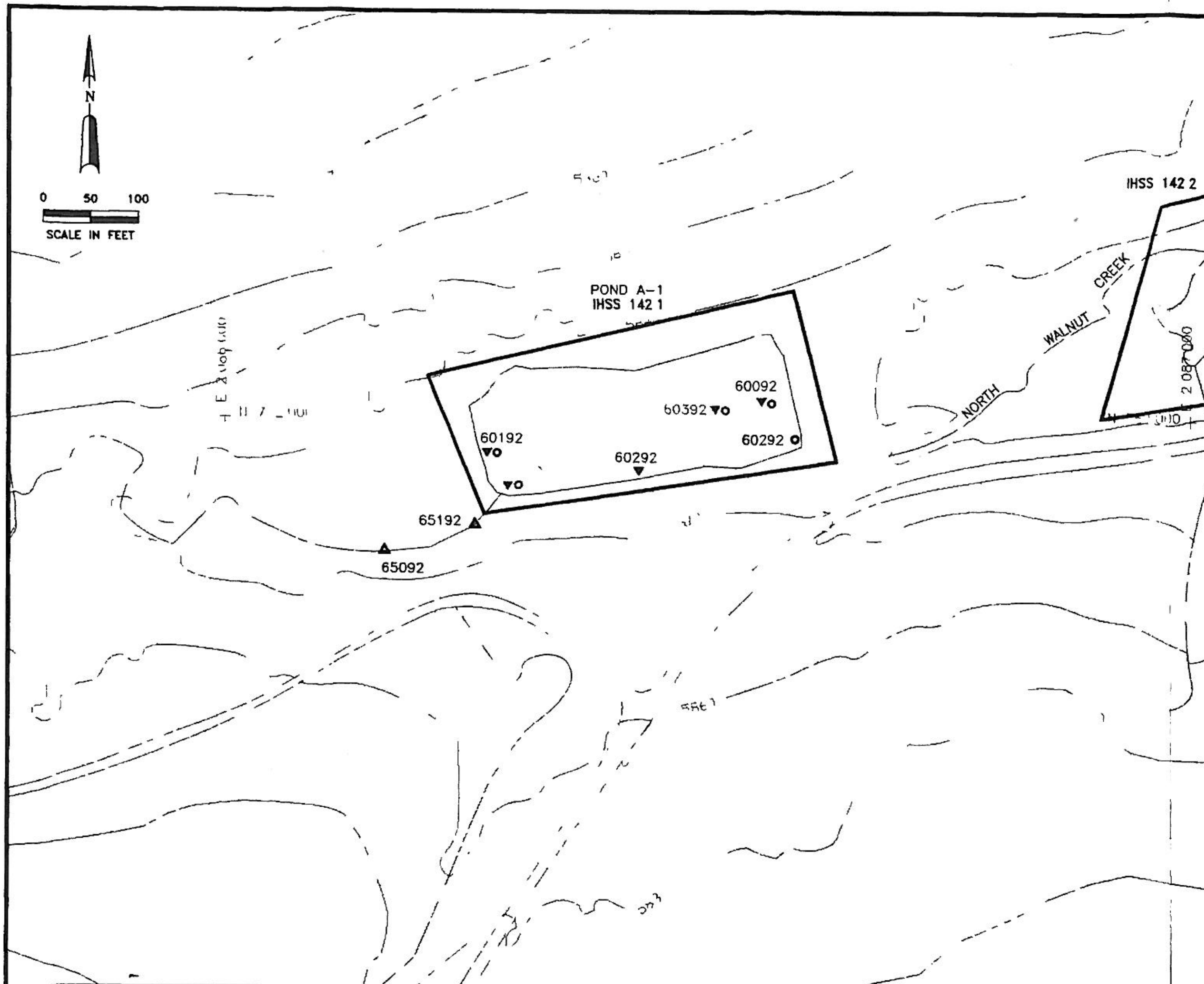
GERMANIUM SURVEY POINTS
FOR IHSSs 141 156 2 AND 165

FIGURE 2 2-2

APRIL 1995

6/9

OU6RI005 1=300



EXPLANATION

IHSS BOUNDARIES

▲ DRY SEDIMENT SAMPLE SITES

▼ WET SEDIMENT SAMPLE SITES

o SURFACE WATER SAMPLE SITES

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
INFLUENT

DRAFT
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NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Golden Colorado

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SURFACE WATER WET SEDIMENT AND DRY SEDIMENT SAMPLE SITES POND A-1 (IHSS 142 1)

FIGURE 2 2-3 APRIL 1995

1/15 3 OU6R007 1=100

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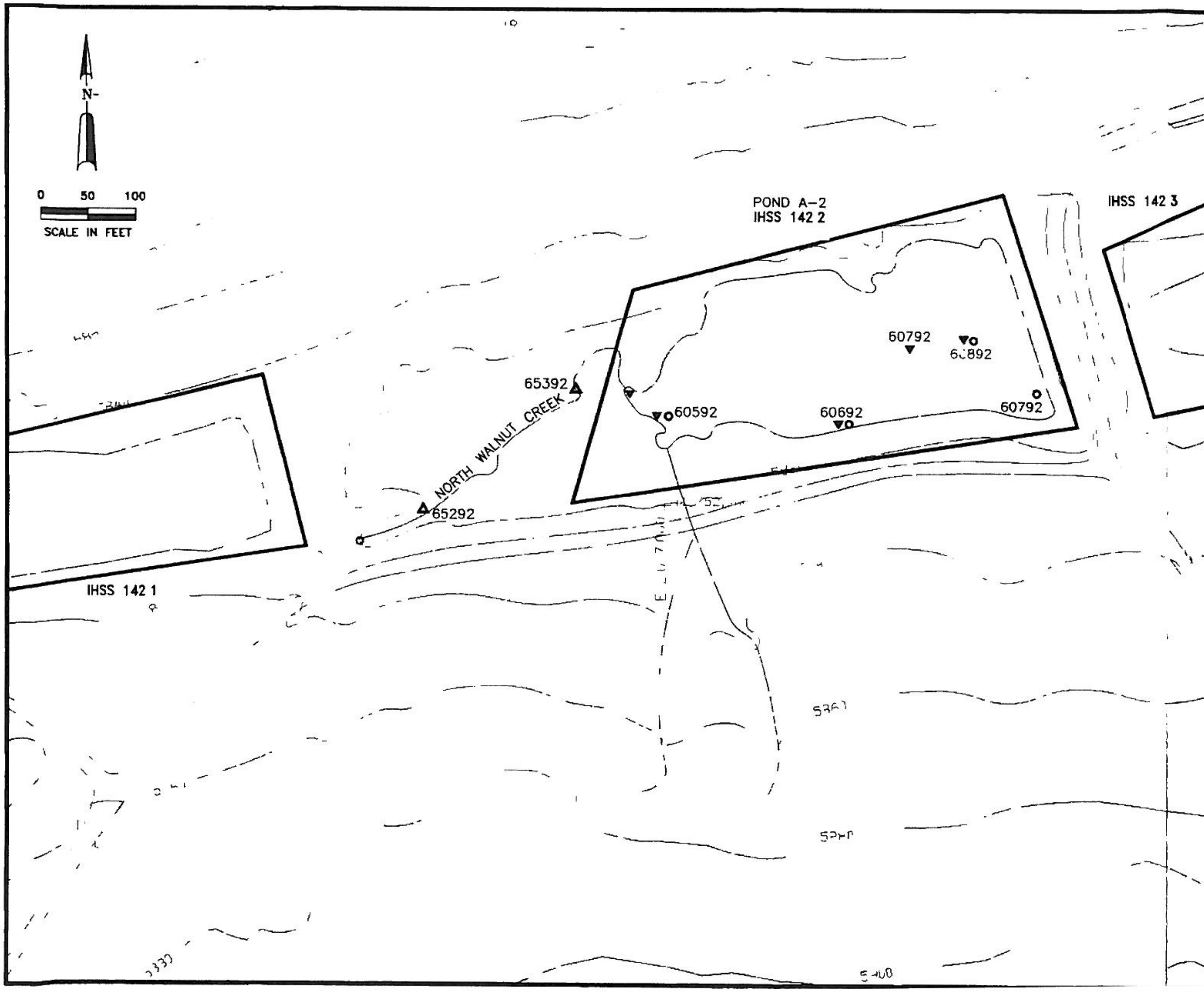
Name/Org. JA Nesheim EMCBC Classn Date 10/14/08



EXPLANATION

IHSS BOUNDARIES

DRY SEDIMENT SAMPLE SITES

WET SEDIMENT SAMPLE SITES

SURFACE WATER SAMPLE SITES

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
INFLUENT

DRAFT
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NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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PHASE I RFI/RI REPORT

SURFACE WATER WET SEDIMENT AND DRY SEDIMENT SAMPLE SITES POND A-2 (IHSS 142 2)

FIGURE 2 2-4

APRIL 1995

1/6/95 OU6R1008 1=100

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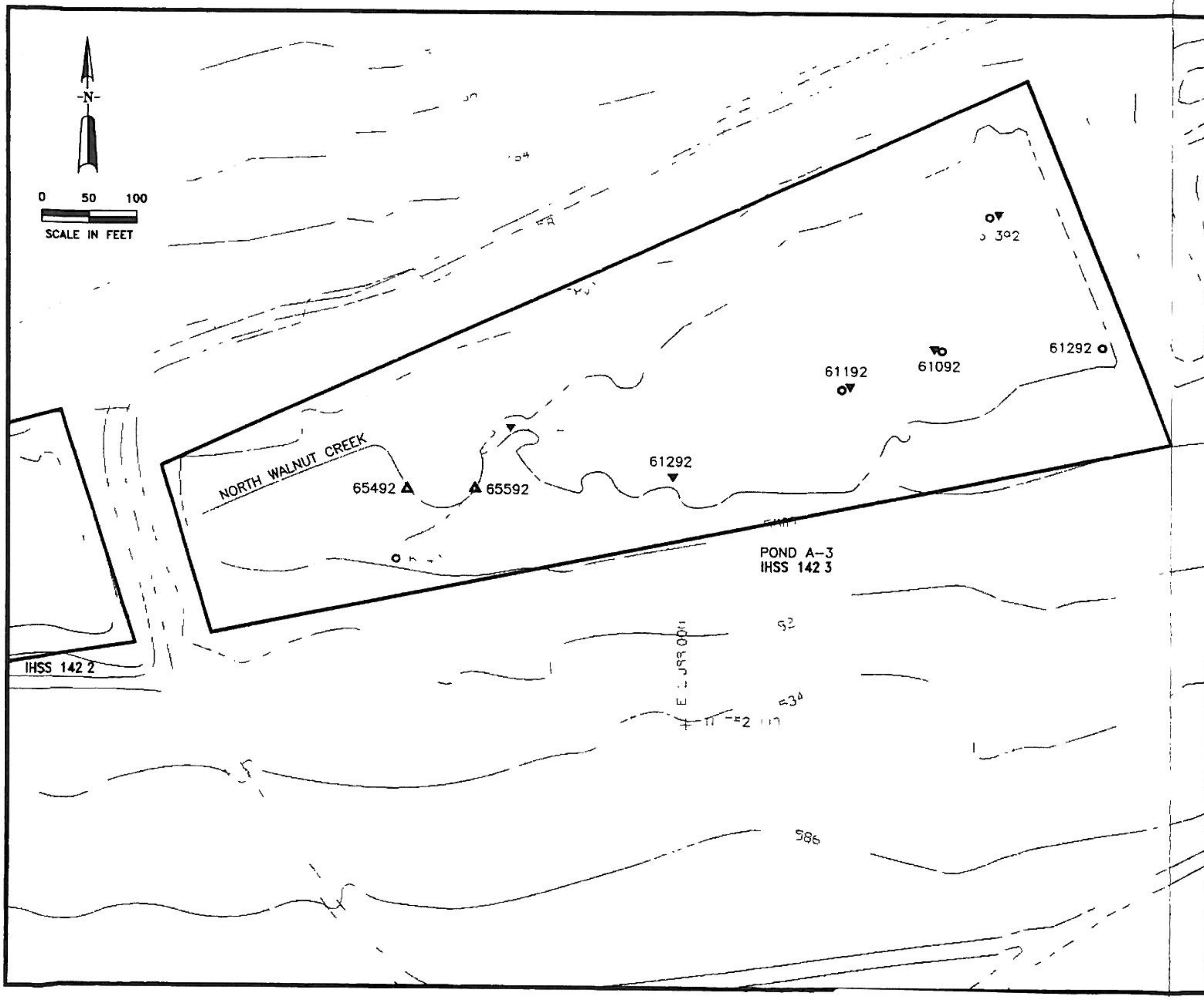
Name/Org. J A Neskein EMCBC Classn Date 10/14/08



EXPLANATION

IHSS BOUNDARIES

▲ DRY SEDIMENT SAMPLE SITES

▼ WET SEDIMENT SAMPLE SITES

o SURFACE WATER SAMPLE SITES

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
INFLUENT

DRAFT
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NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Golden Colorado

OPERABLE UNIT NO 6
PHASE I RFI/RI REPORT

SURFACE WATER WET SEDIMENT AND DRY SEDIMENT SAMPLE SITES POND A-3 (IHSS 142 3)

FIGURE 2 2-5 APRIL 1995

1 6/9 OU6R009 1=100

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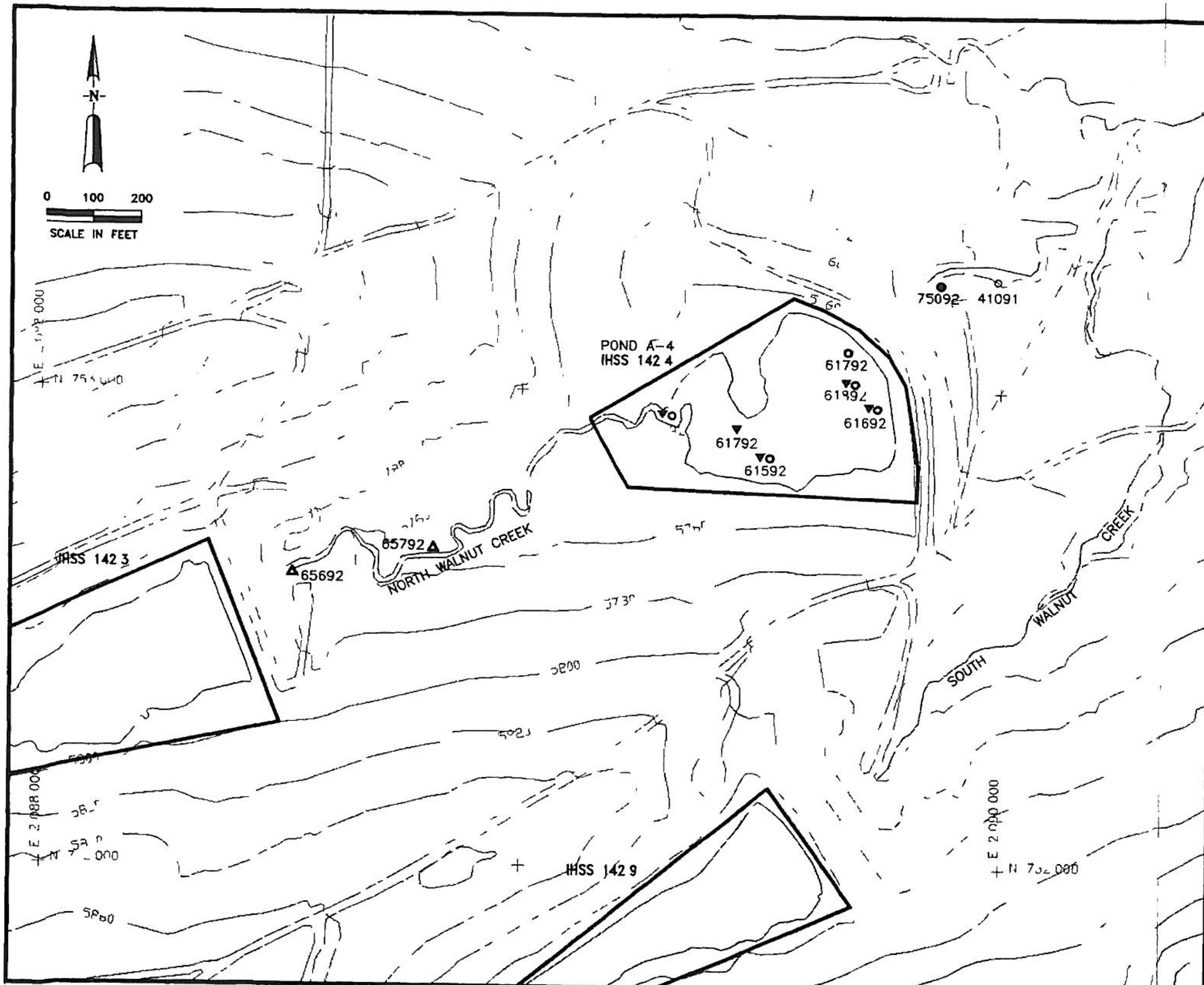
Name/Org. J A Nesheim / EMSC Classm Date 2/14/08



EXPLANATION

IHSS BOUNDARIES

- DRY SEDIMENT SAMPLE SITES
- WET SEDIMENT SAMPLE SITES
- SURFACE WATER SAMPLE SITES
- HISTORIC MONITORING WELL (ALLUVIAL)
- MONITORING WELL (BEDROCK)

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
INFLUENT

DRAFT
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NO

SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Golden Colorado

OPERABLE UNIT NO 6
PHASE I RFI/RI REPORT

SURFACE WATER WET SEDIMENT
DRY SEDIMENT SAMPLE SITES
AND MONITORING WELL LOCATIONS
POND A-4 (IHSS 142 4)

FIGURE 2 2-6 APRIL 1995

1/1 /95 OU6R010 1=200

DOES NOT CONTAIN
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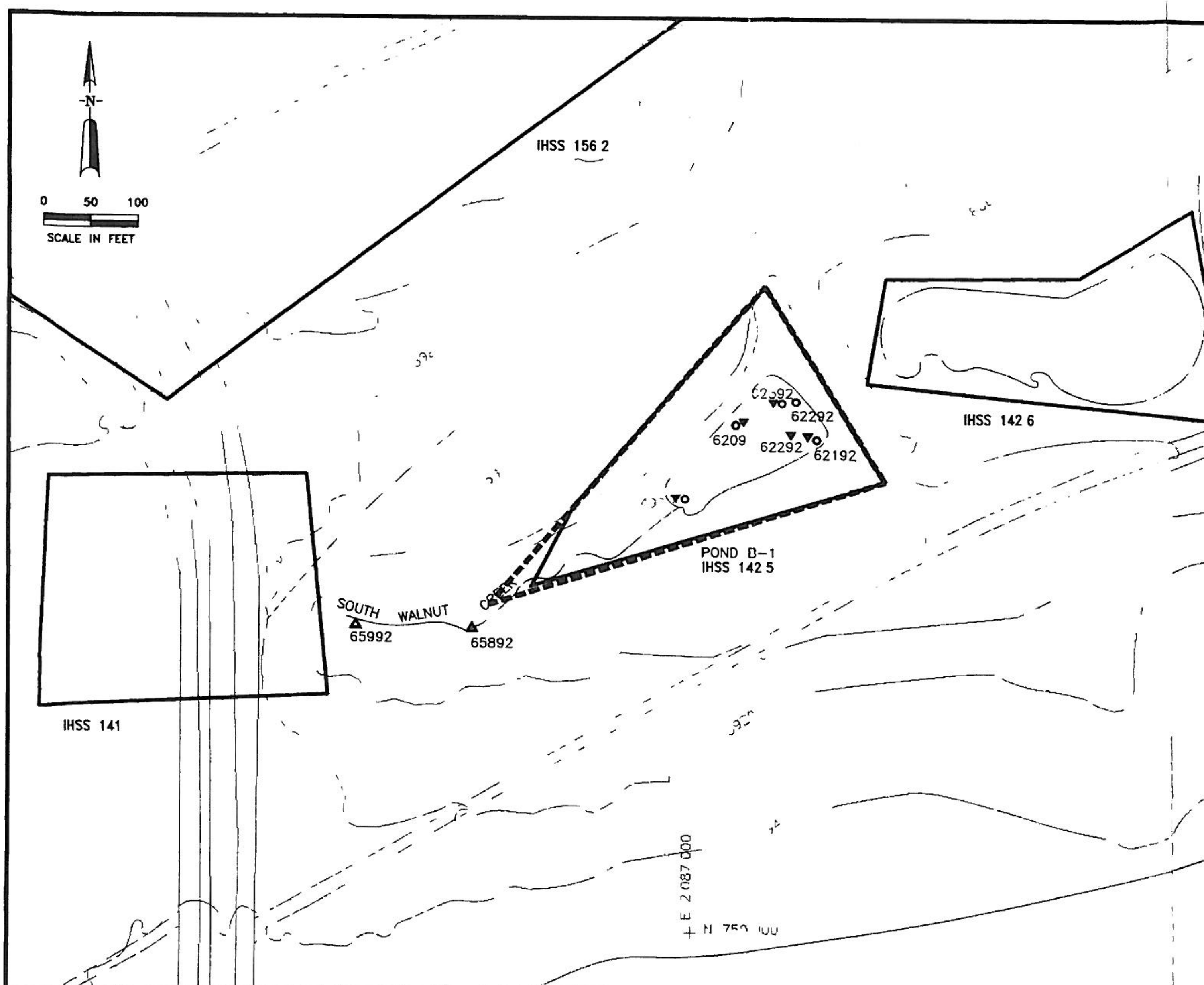
Name/Org CA Nesheim EMCBC Classification Date 10/14/08



EXPLANATION

IHSS BOUNDARIES

HISTORICAL IHSS BOUNDARY DOE 1987

▲ DRY SEDIMENT SAMPLE SITES

▼ WET SEDIMENT SAMPLE SITES

o SURFACE WATER SAMPLE SITES

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
INFLUENT

DRAFT
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NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Golden Colorado

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PHASE I RFI/RI REPORT

SURFACE WATER WET SEDIMENT AND DRY SEDIMENT SAMPLE SITES POND B-1 (IHSS 142 5)

FIGURE 2 2-7 APRIL 1995

1/6/95 OU6R011 1-100

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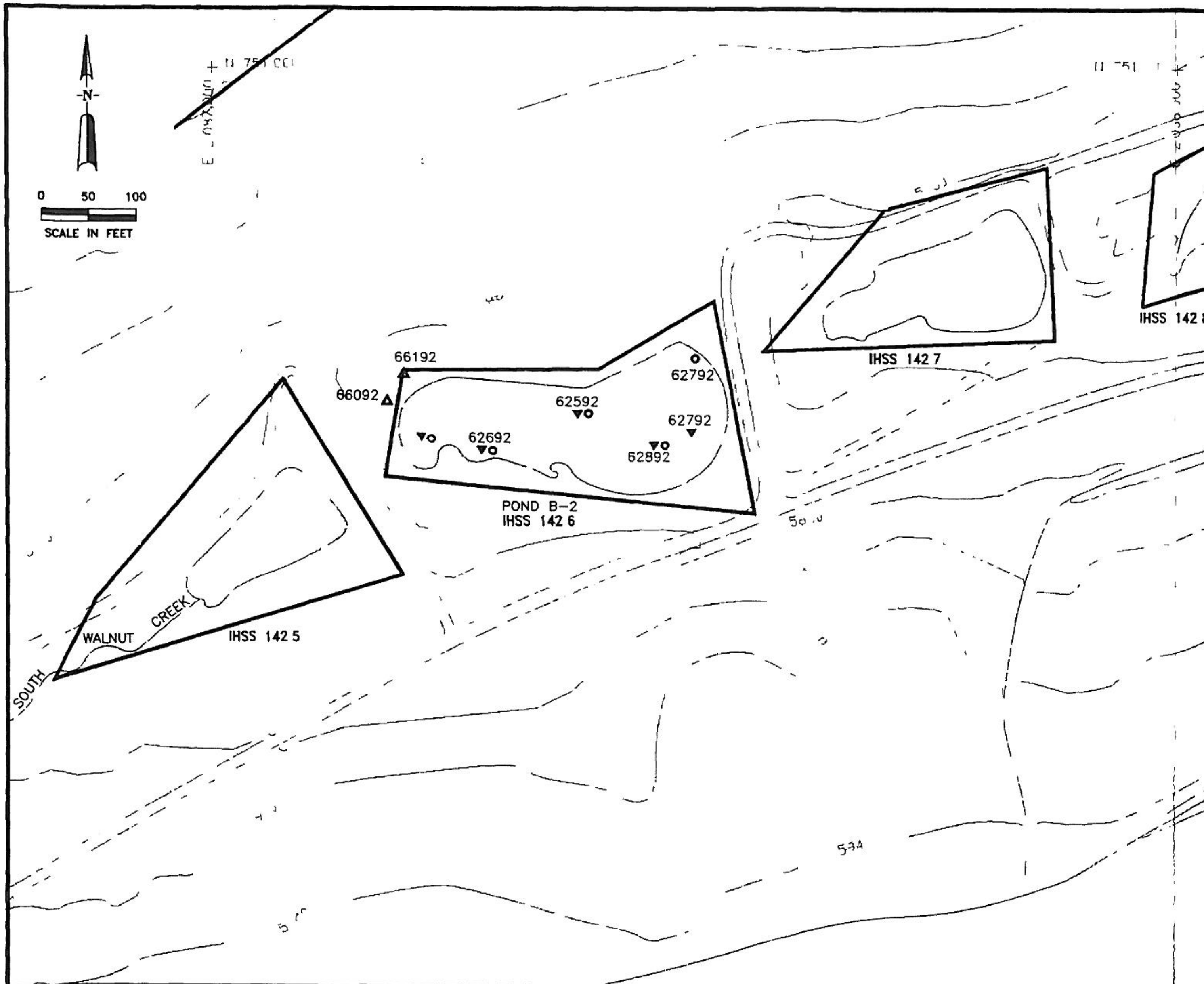
Name/Org J Nesheim EMCBC Classm Date 10/14/08



EXPLANATION

IHSS BOUNDARIES

△ DRY SEDIMENT SAMPLE SITES

▼ WET SEDIMENT SAMPLE SITES

o SURFACE WATER SAMPLE SITES

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
NFLUENT

DRAFT
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NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Golden Colorado

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PHASE I RFI/RI REPORT

SURFACE WATER WET SEDIMENT AND DRY SEDIMENT SAMPLE SITES POND B-2 (IHSS 142 6)

FIGURE 2 2-8 APRIL 1995

1/6/95 OU6R012 1=100

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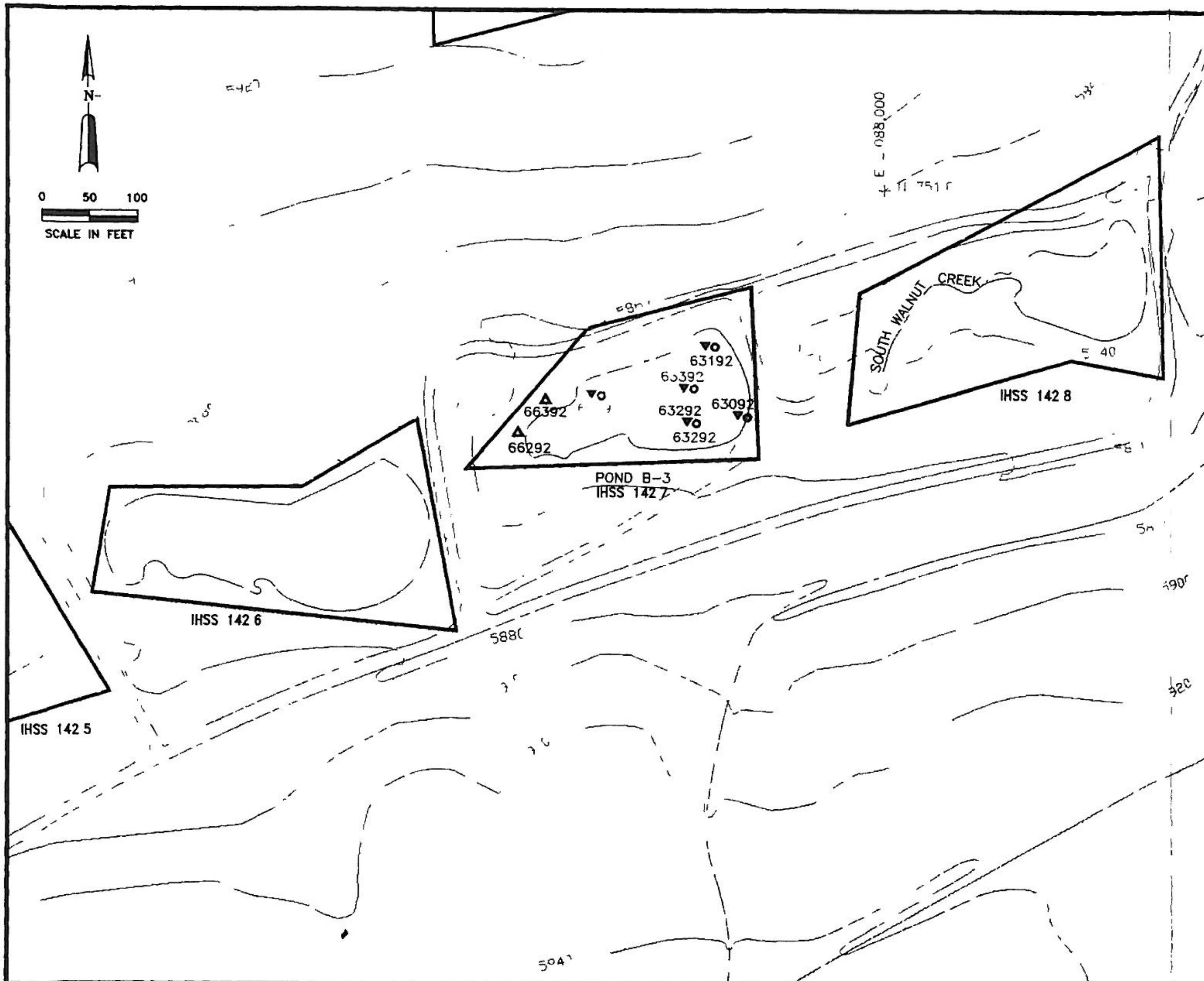
Name/Org: J A Nesheim EMCBC Classm Date: 10/14/08



EXPLANATION

IHSS BOUNDARIES

▲ DRY SEDIMENT SAMPLE SITES

▼ WET SEDIMENT SAMPLE SITES

o SURFACE WATER SAMPLE SITES

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
NFLUENT

DRAFT
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NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Rocky Flats Environmental Technology Site
Golden Colorado

OPERABLE UNIT NO 6
PHASE I RFI/RI REPORT

SURFACE WATER WET SEDIMENT AND DRY SEDIMENT SAMPLE SITES POND B-3 (IHSS 142 7)

FIGURE 2 2-9 APRIL 1995

OU6R013 1=100

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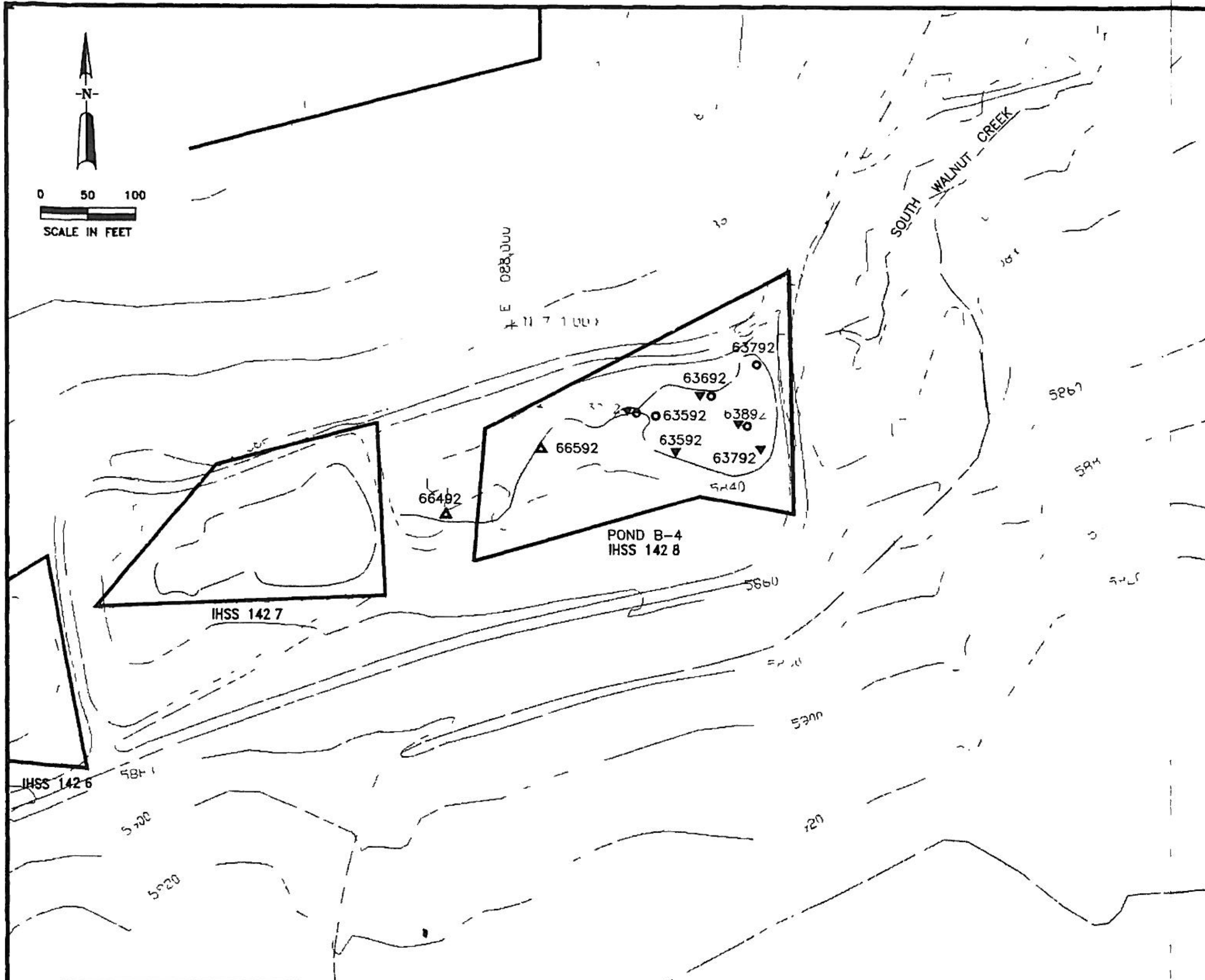
Name/Org A Nesheim ENCSC Classn Date 12/14/08



EXPLANATION

IHSS BOUNDARIES

▲ DRY SEDIMENT SAMPLE SITES

▼ WET SEDIMENT SAMPLE SITES

o SURFACE WATER SAMPLE SITES

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
INFLUENT

DRAFT
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NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Rocky Flats Environmental Technology Site
Golden Colorado

OPERABLE UNIT NO 6
PHASE I RFI/RI REPORT

SURFACE WATER WET SEDIMENT AND DRY SEDIMENT SAMPLE SITES POND B-4 (IHSS 142 8)

FIGURE 2 2-10 APRIL 1995
6/8 OU6R014 1=100

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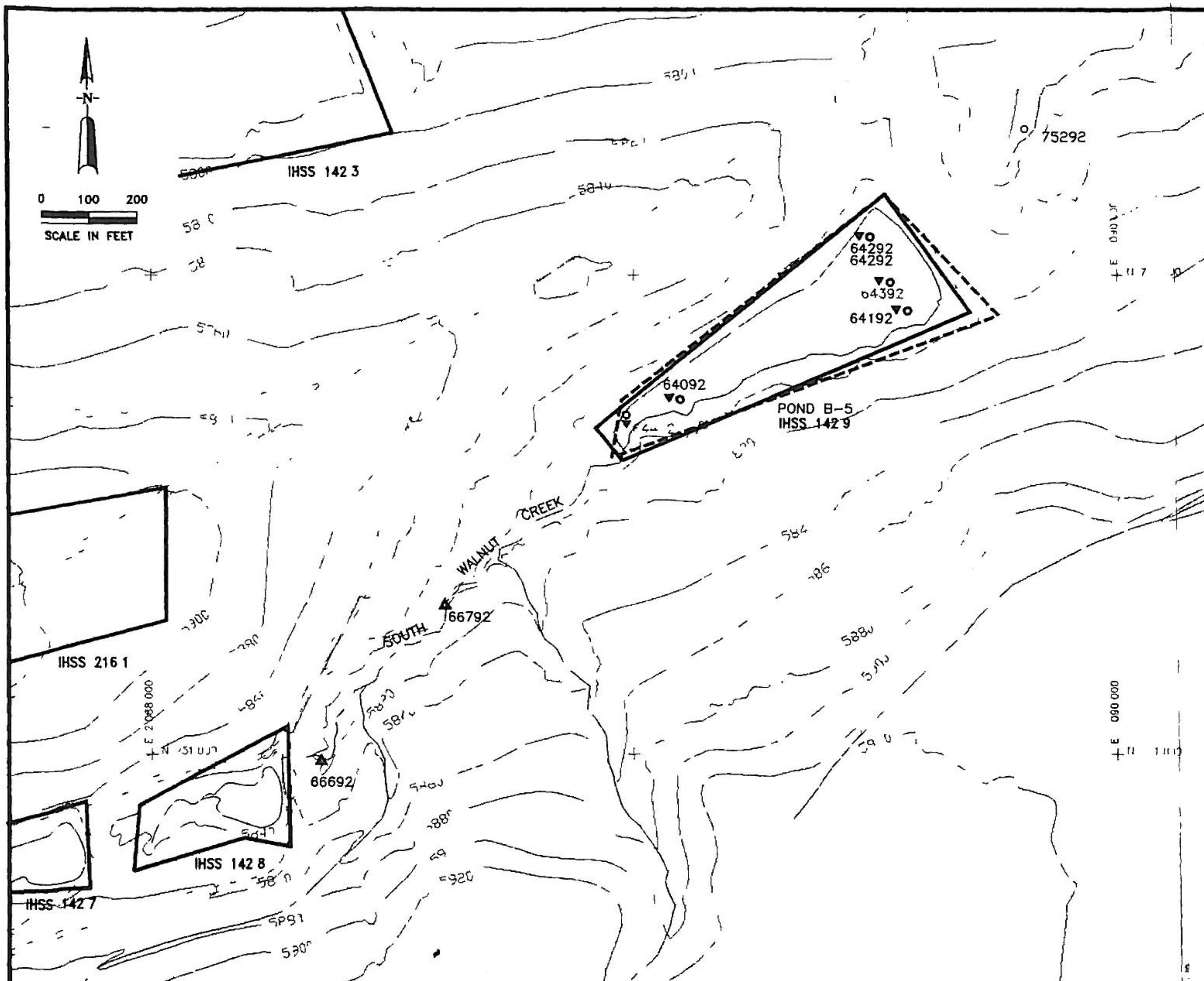
Name/Org. J A Nesheim EMCBC Classif Date 10/14/08



EXPLANATION

IHSS BOUNDARIES

HISTORICAL IHSS BOUNDARY DOE 1987

DRY SEDIMENT SAMPLE SITES

WET SEDIMENT SAMPLE SITES

SURFACE WATER SAMPLE SITES

MONITORING WELL (ALLUVIAL)

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
INFLUENT

DRAFT
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~~Not approved for distribution~~

NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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Rocky Flats Environmental Technology Site
Golden Colorado

OPERABLE UNIT NO 6
PHASE I RFI/RI REPORT

SURFACE WATER WET SEDIMENT DRY SEDIMENT SAMPLE SITES AND MONITORING WELL LOCATION POND B-5 (IHSS 142 9)

FIGURE 2 2-11 APRIL 1995

5/17/95 DU6R015 1 200

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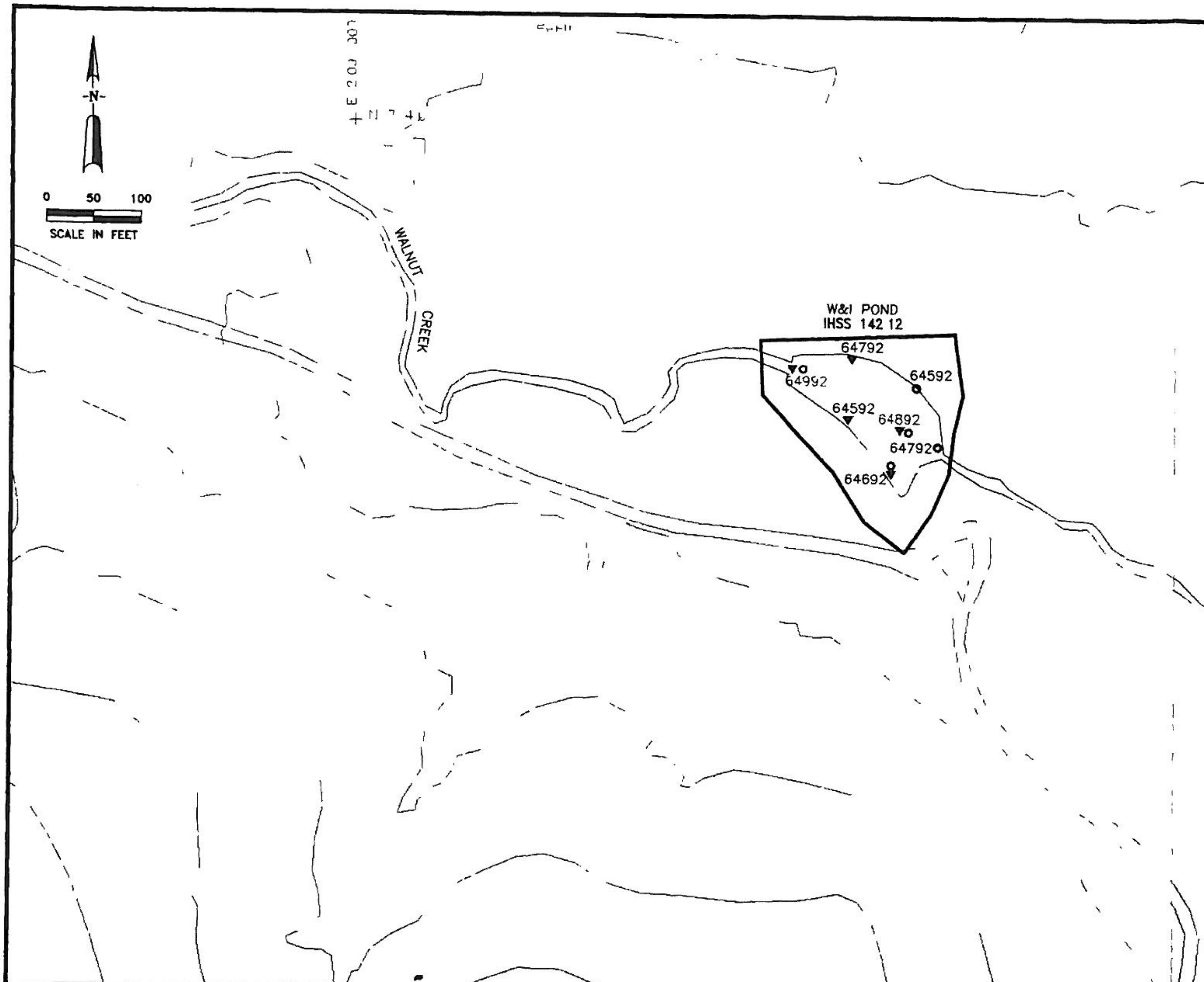
Name/Org. [signature] EMCBC [illegible] Date 10/14/08



EXPLANATION

IHSS BOUNDARIES

▼ WET SEDIMENT SAMPLE SITES

o SURFACE WATER SAMPLE SITES

SAMPLING LOCATIONS WITHIN A POND ARE COLOR CODED AS FOLLOWS

RANDOM
EFFLUENT
DEEP
INFLUENT

DRAFT
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~~Not approved for distribution~~

NOTE
SAMPLE NUMBER ON MAP IS AN ABBREVIATION OF SAMPLE I D SURFACE WATER AND SEDIMENT SAMPLES HAVE THE SAME NUMBER IN THE RFEDS DATA BASE BUT ARE PREFIXED WITH SW OR SED RESPECTIVELY

SED60392 SEDIMENT SAMPLE
SW60392 SURFACE WATER SAMPLE

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SURFACE WATER AND WET SEDIMENT SAMPLE SITES
W&I POND (IHSS 142 12)

FIGURE 2 2-12 APRIL 1995

I 6/95 OU6R016 1=100

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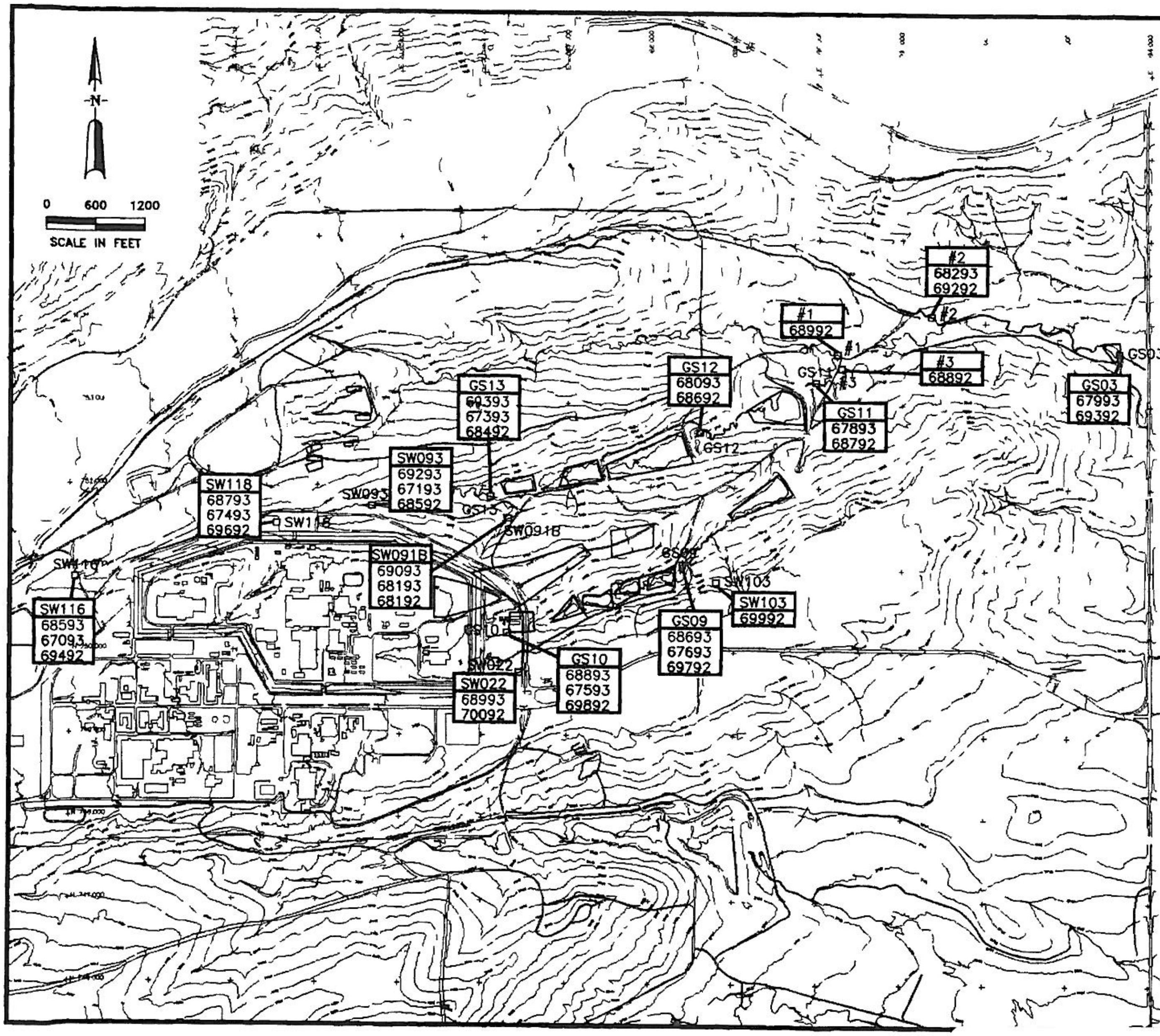

EXPLANATION

IHSS BOUNDARIES

SAMPLE LOCATIONS

SW118 – SURFACE WATER STATION #118
OR GS11 – GAUGING STATION #11

SW118	SAMPLE SITE NUMBERS BY MEDIUM
68793	SURFACE WATER (STORM EVENT)
67493	SURFACE WATER (BASEFLOW)
69692	SEDIMENT

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STREAM SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS

FIGURE 2 2-13 APRIL 1995

3 17 95 DU6R017 1=1200

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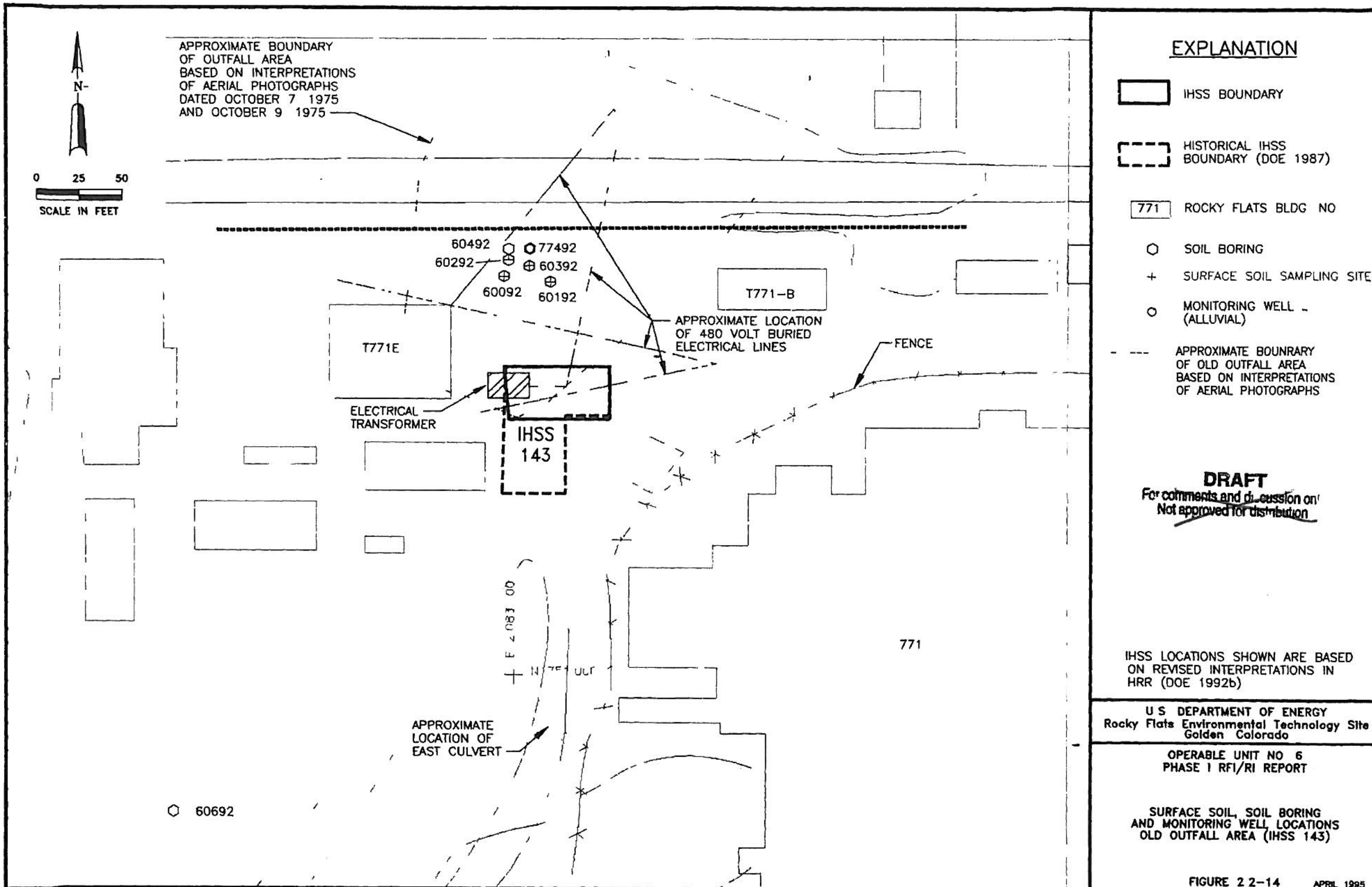

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SURFACE SOIL, SOIL BORING AND MONITORING WELL LOCATIONS OLD OUTFALL AREA (IHSS 143)

FIGURE 2 2-14 APRIL 1995

71 /95 OU6RI018 1=50

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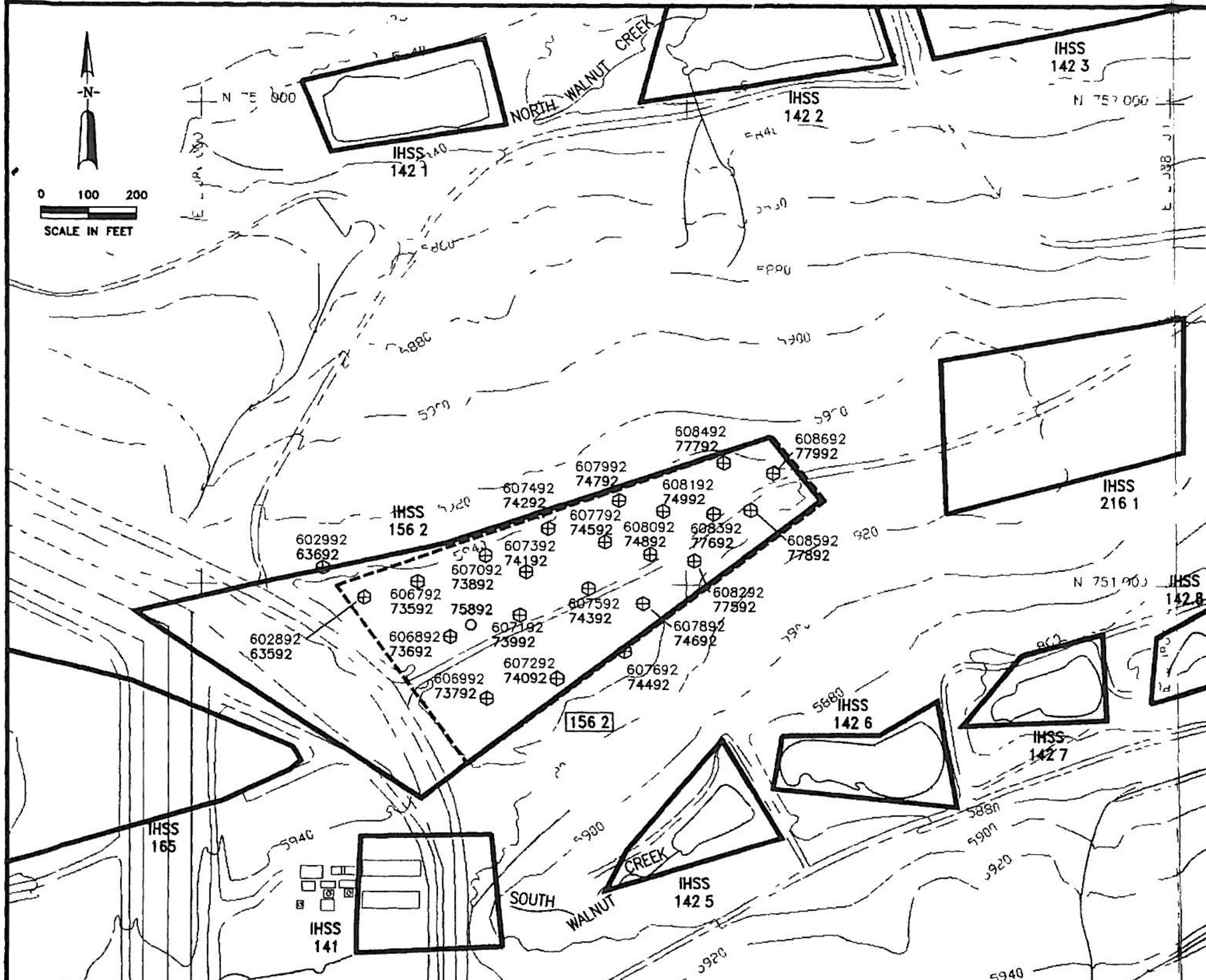

EXPLANATION

IHSS BOUNDARIES

156 2 HISTORICAL IHSS BOUNDARY (DOE 1987)

\+ SURFACE SOIL SAMPLING SITE

SOIL BORING

75892 MONITORING WELL (ALLUVIAL)

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SURFACE SOIL AND SUBSURFACE SOIL SAMPLE LOCATIONS AND MONITORING WELL LOCATION (IHSS 156 2)

FIGURE 2 2-15 APRIL 1995

1/12/95 OU6R019 1=200

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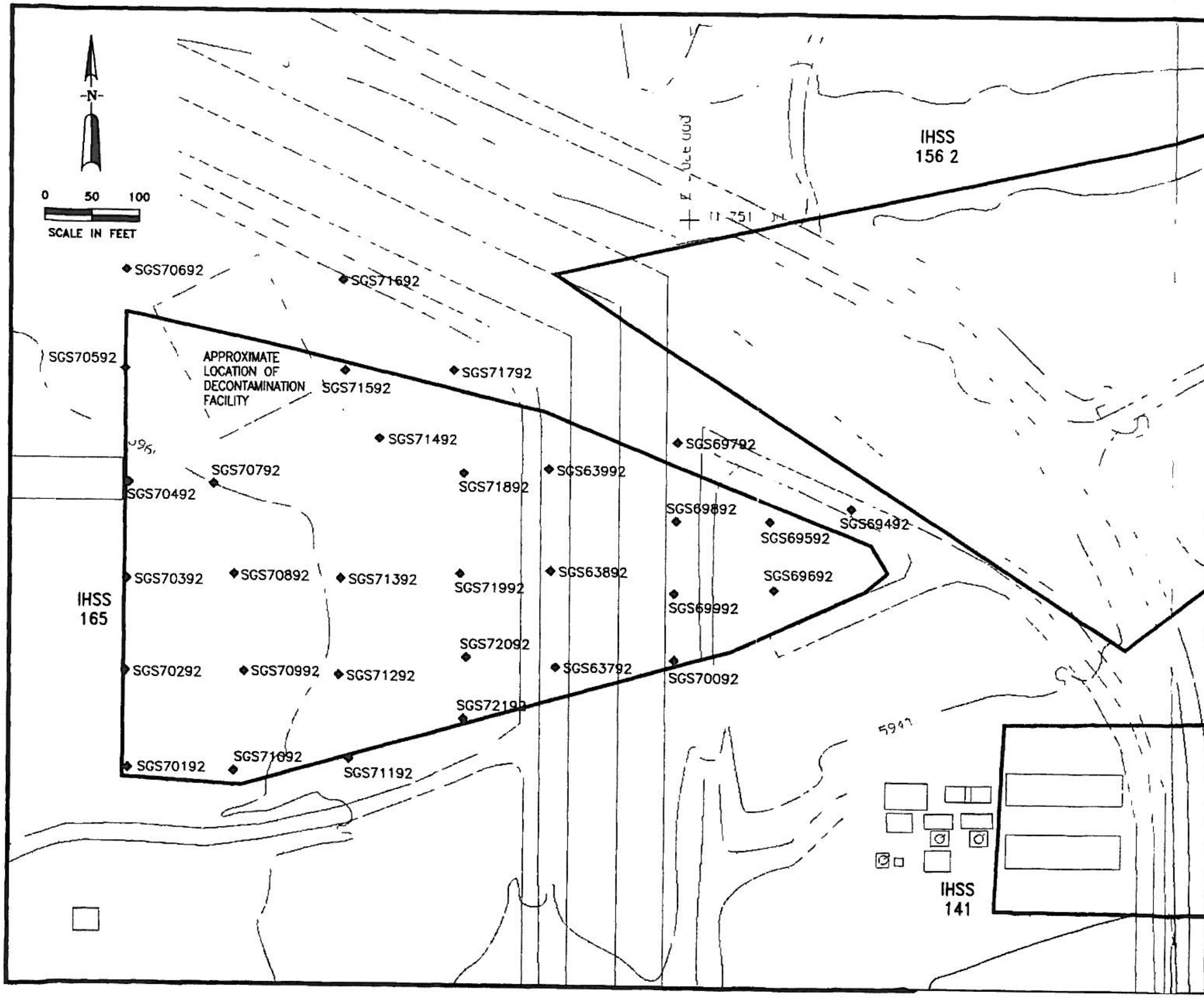

EXPLANATION

IHSS BOUNDARIES

SGS69492 — APPROXIMATE SOIL-GAS SURVEY SAMPLE SITE

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SOIL GAS SAMPLE LOCATIONS
(IHSS 165)

FIGURE 2 2-16 APRIL 1995

1/12/95 OU6R027 1-100

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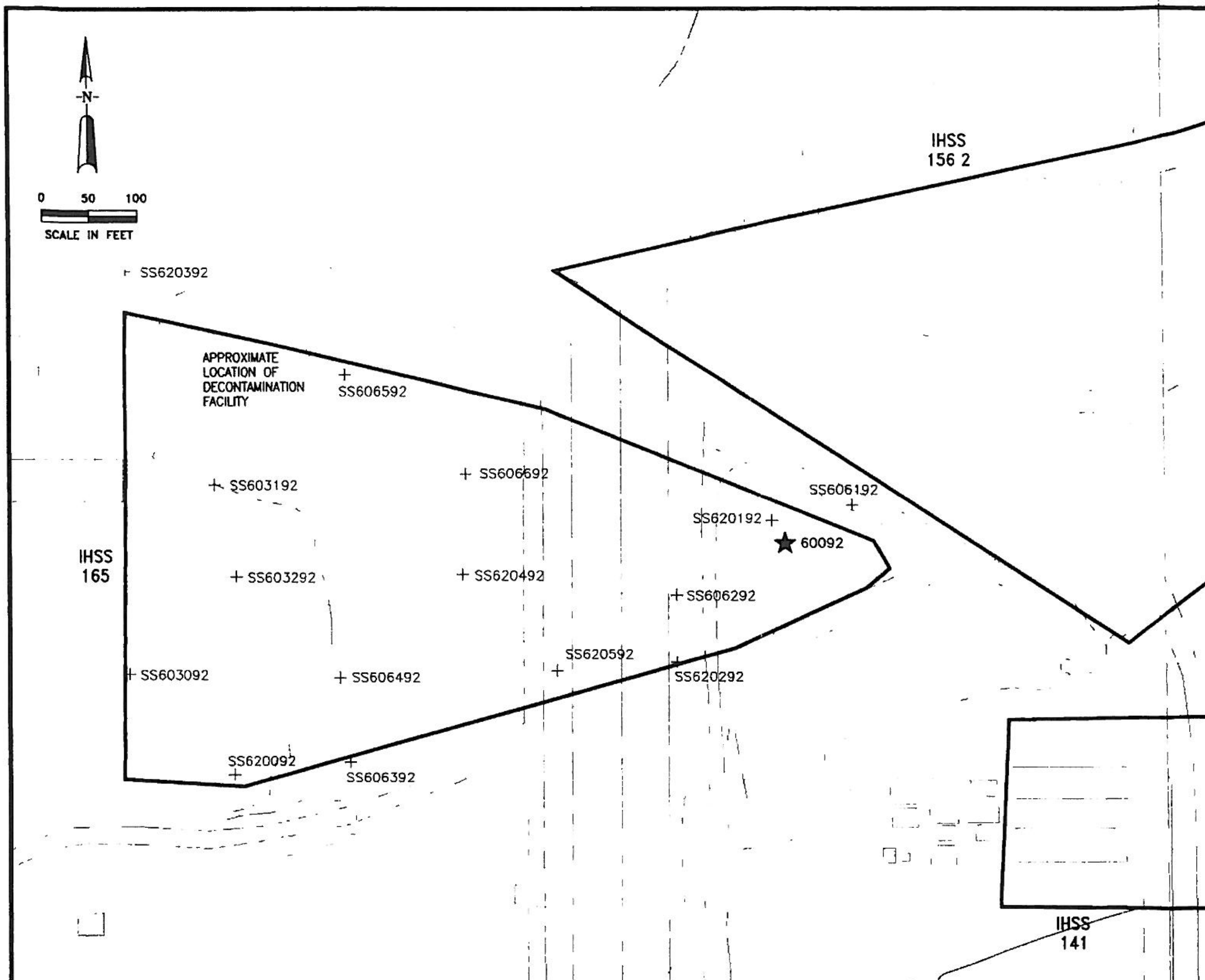

EXPLANATION

IHSS BOUNDARIES

\+ APPROXIMATE SURFACE SOIL SAMPLING SITE

★ SOIL PROFILES PIT

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SURFACE SOIL SAMPLING LOCATIONS AND LOCATION OF SOIL PROFILE PIT 60092 (IHSS 165)

FIGURE 2 2-17

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OU6R020 1=100

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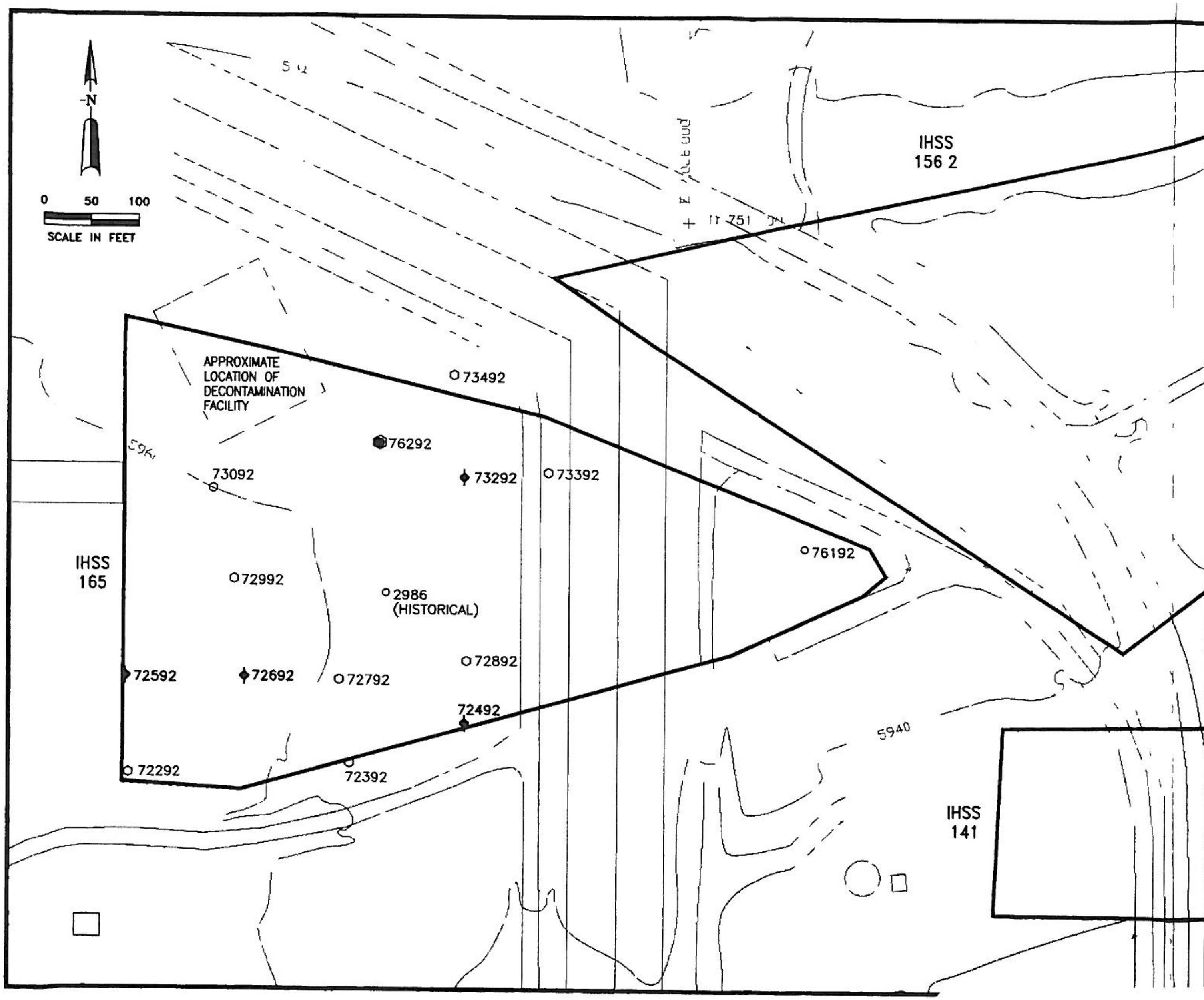

EXPLANATION

- IHSS BOUNDARIES
- MONITORING WELL (BEDROCK)
- MONITORING WELL (ALLUVIAL)
- SOIL CORE
- SOIL BORING

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SOIL CORE SOIL BORING AND MONITORING WELL LOCATIONS (IHSS 165)

FIGURE 2 2-18 APRIL 1995
1/9/95 OU6R021 1=100

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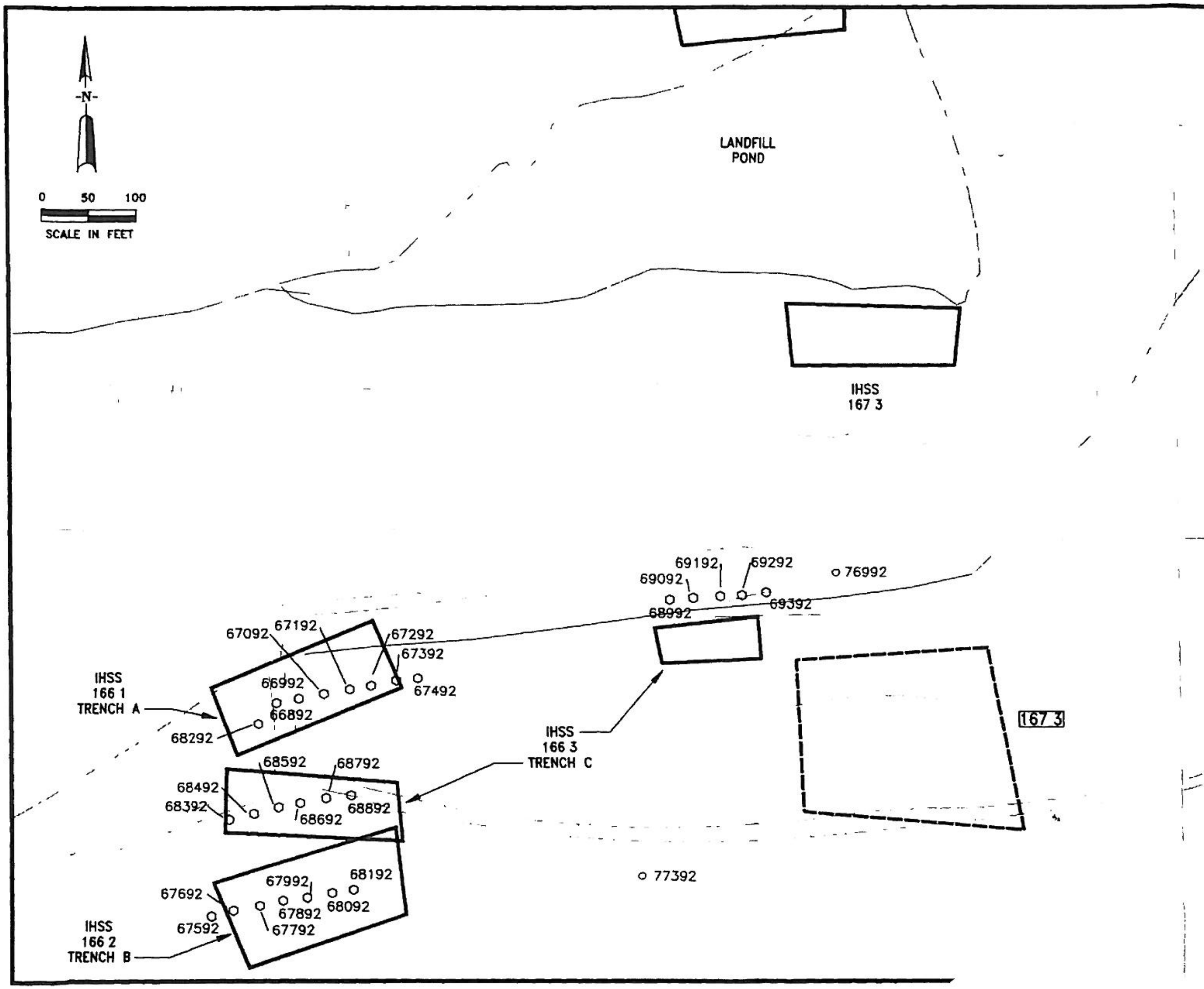

EXPLANATION

IHSS BOUNDARIES

HISTORICAL IHSS BOUNDARY (DOE 1987)
167 3

SOIL BORING

MONITORING WELL (ALLUVIAL)
76992

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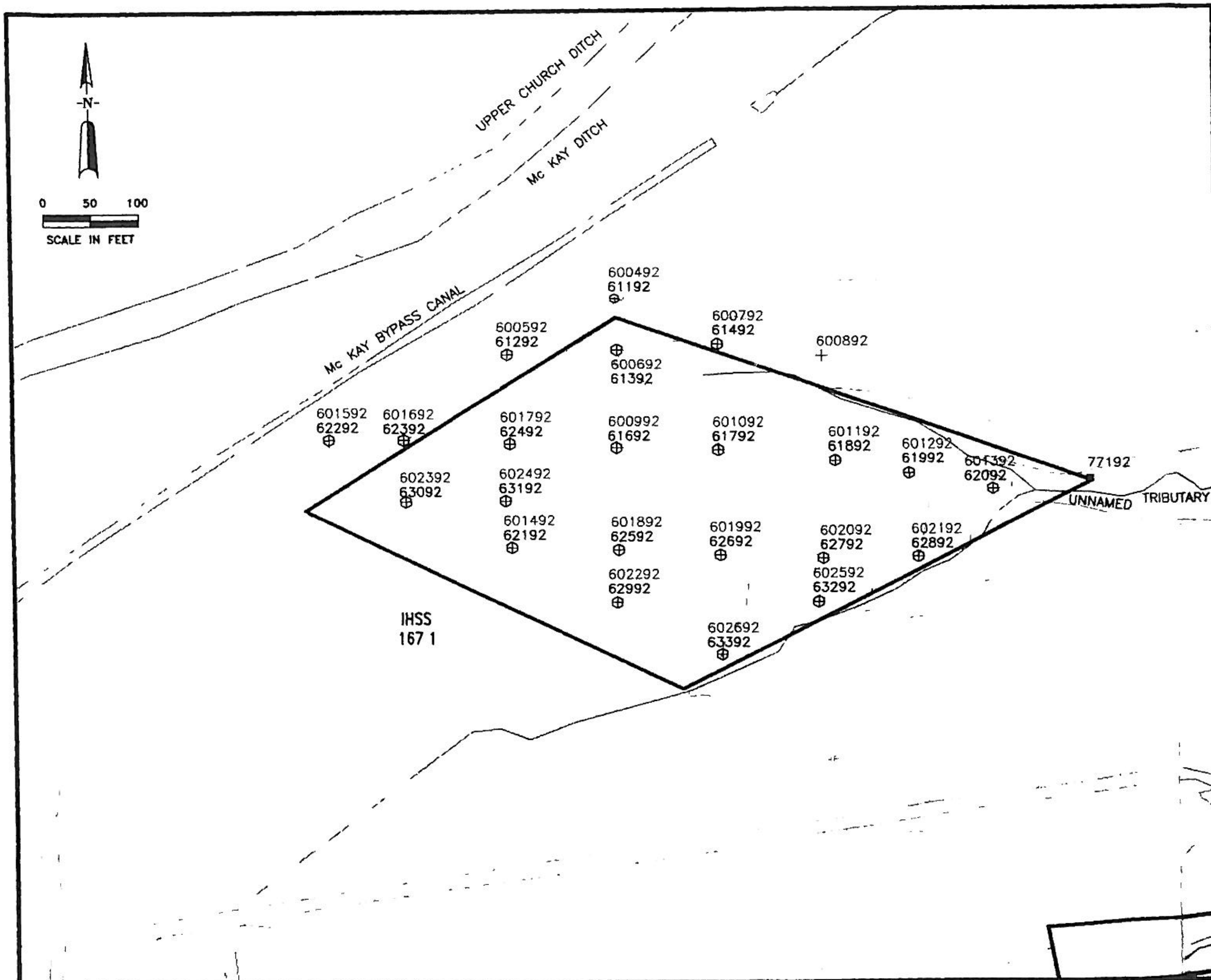
SOIL BORING AND MONITORING WELL LOCATIONS (IHSSs 166 1-3)

FIGURE 2 2-19 APRIL 1995

95 OU6RI110 1=100



EXPLANATION

IHSS BOUNDARIES

+ SURFACE SOIL SAMPLING SITE

○ SOIL BORING

■ MONITORING WELL (COLLUVIAL)

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SURFACE SOIL SOIL BORING AND MONITORING WELL LOCATIONS (IHSS 167 1)

FIGURE 2 2-20 APRIL 1995

OU6R024 1=100

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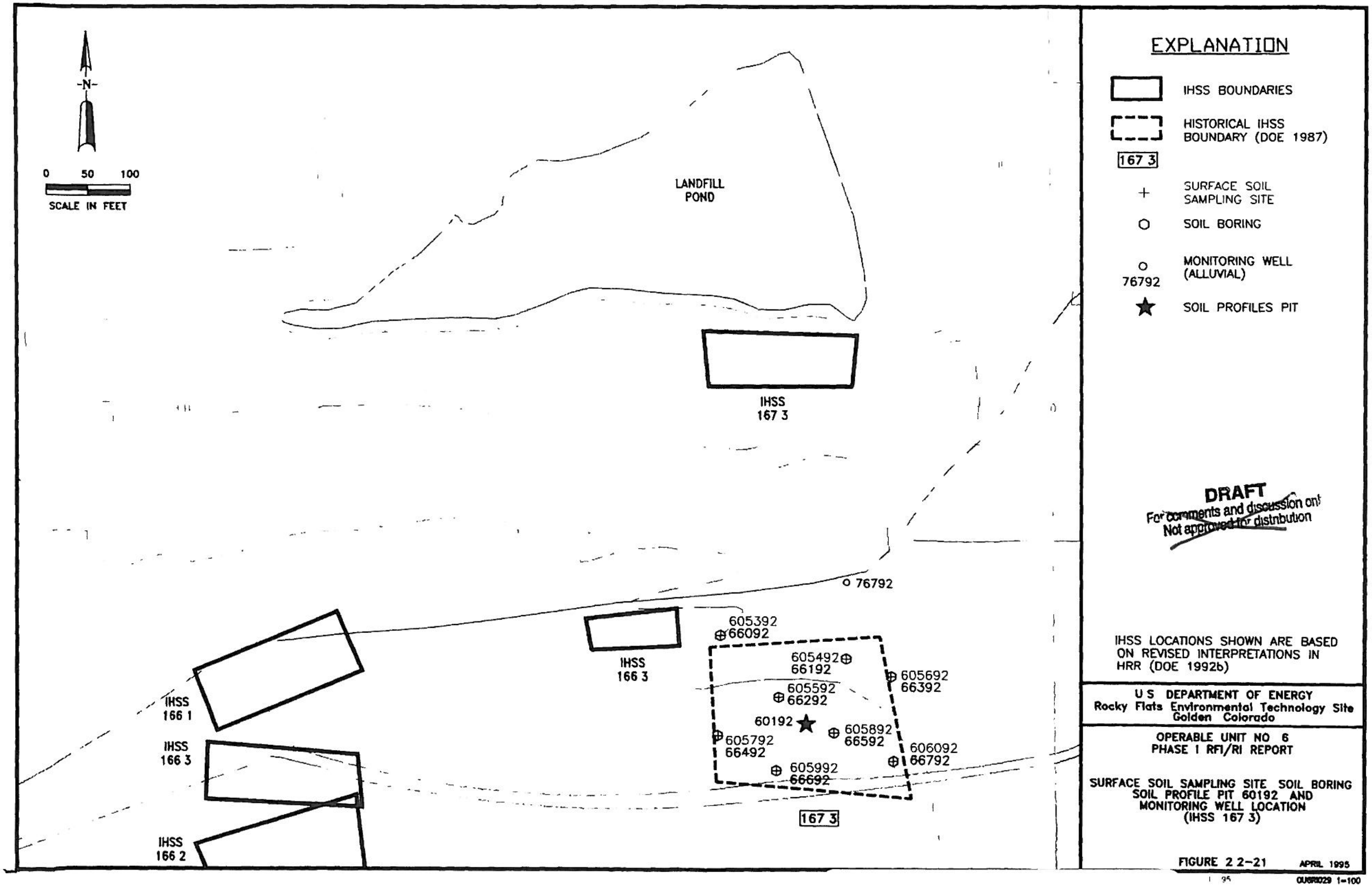

FIGURE 2 2-21

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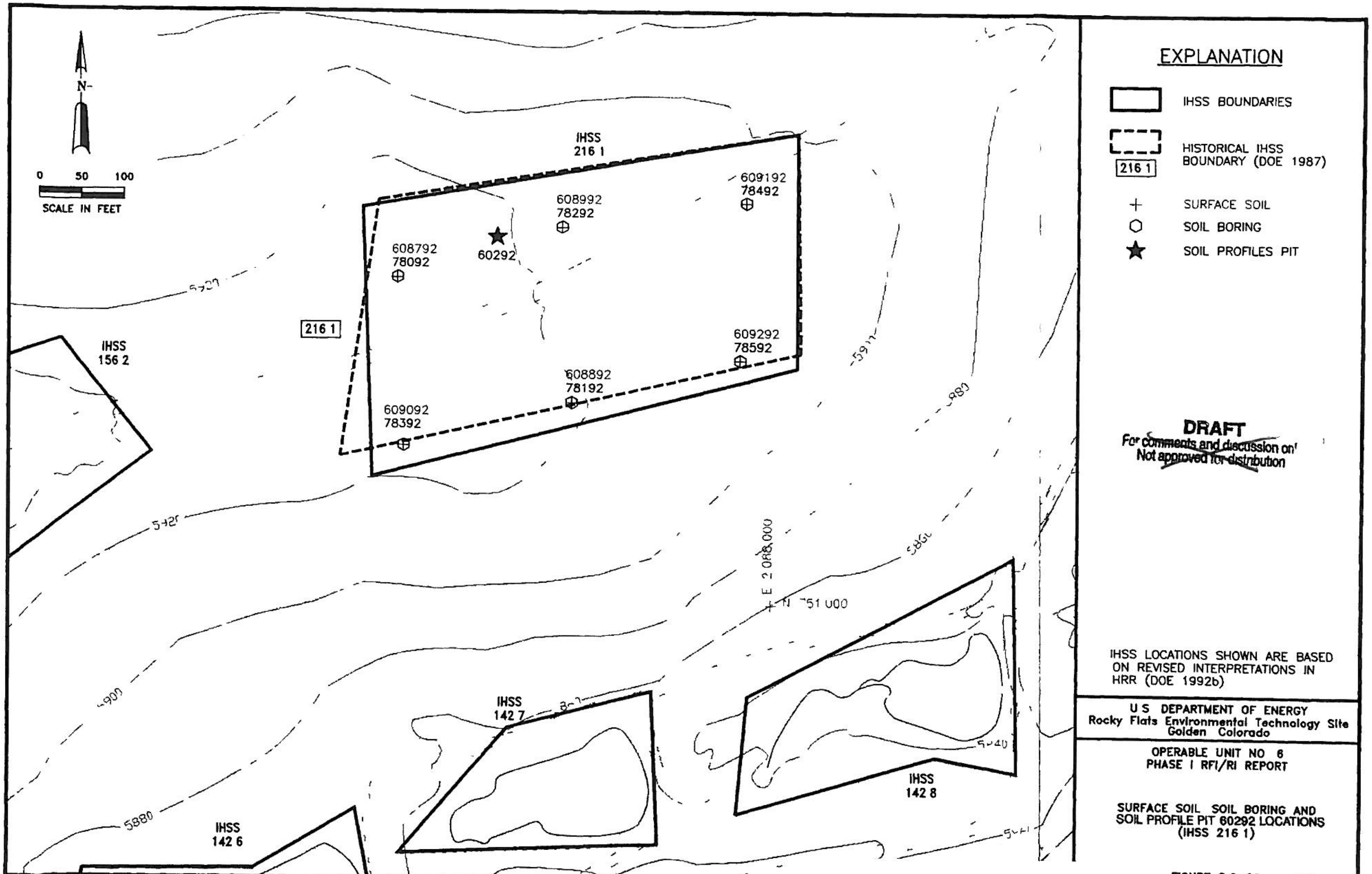

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SURFACE SOIL SOIL BORING AND SOIL PROFILE PIT 60292 LOCATIONS (IHSS 216 1)

FIGURE 2 2-22 APRIL 1995

1/12/95 OU6R025 1=100

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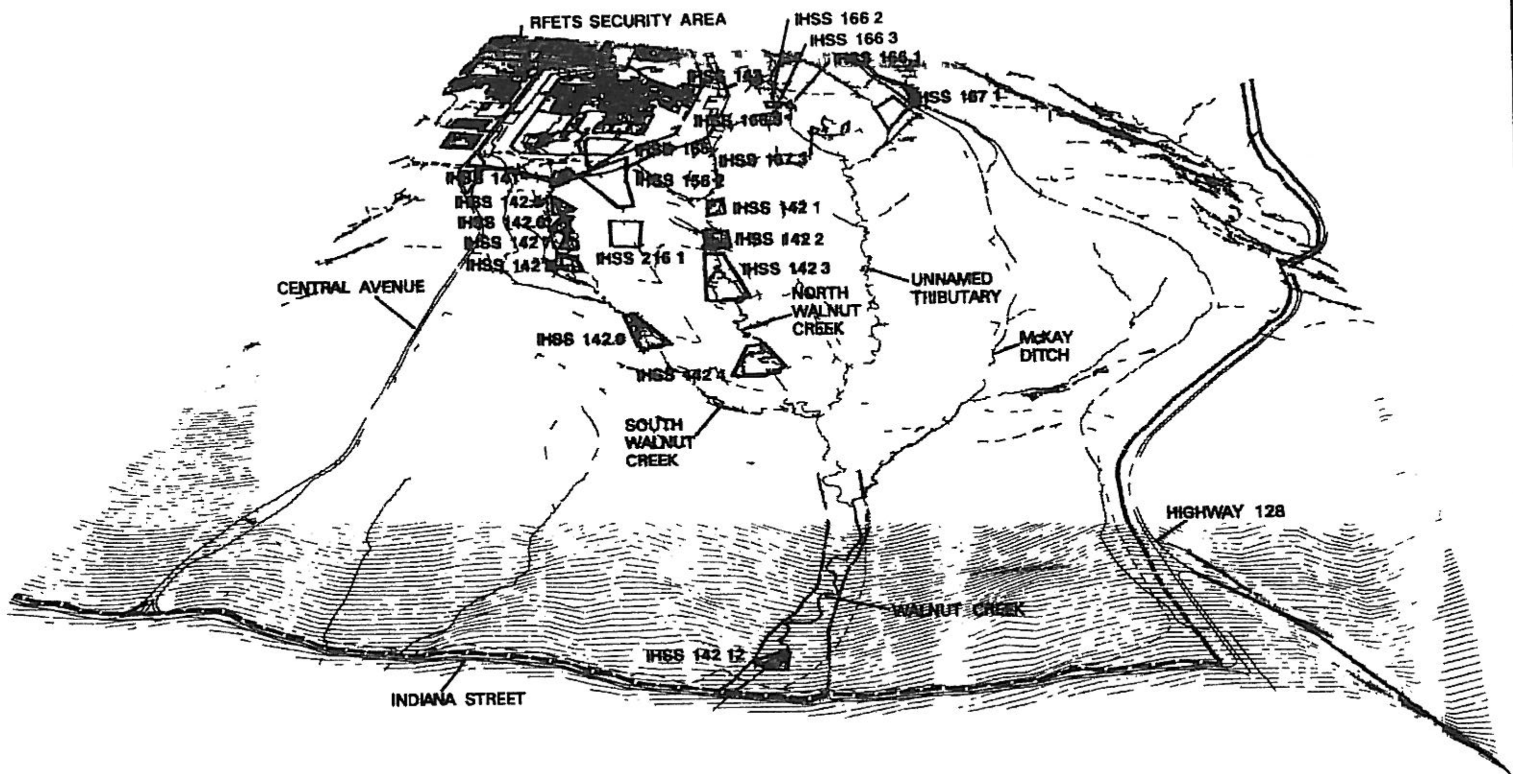

PERSPECTIVE VIEW LOOKING WEST

EXPLANATION

- RFETS Perimeter Fence
- Paved roads
- Dirt Roads
- OU6 Study Area
- Individual Hazardous Substance Sites (IHSSs)
- RFETS Surface Model
- Ponds Lakes and Streams
- Buildings or Other Structures

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Azimuth 80 degrees
Altitude 20 degrees above horizon
Z factor 3

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THREE DIMENSIONAL SURFACE MAP
OU6 STUDY AREA

FIGURE 3.1 1

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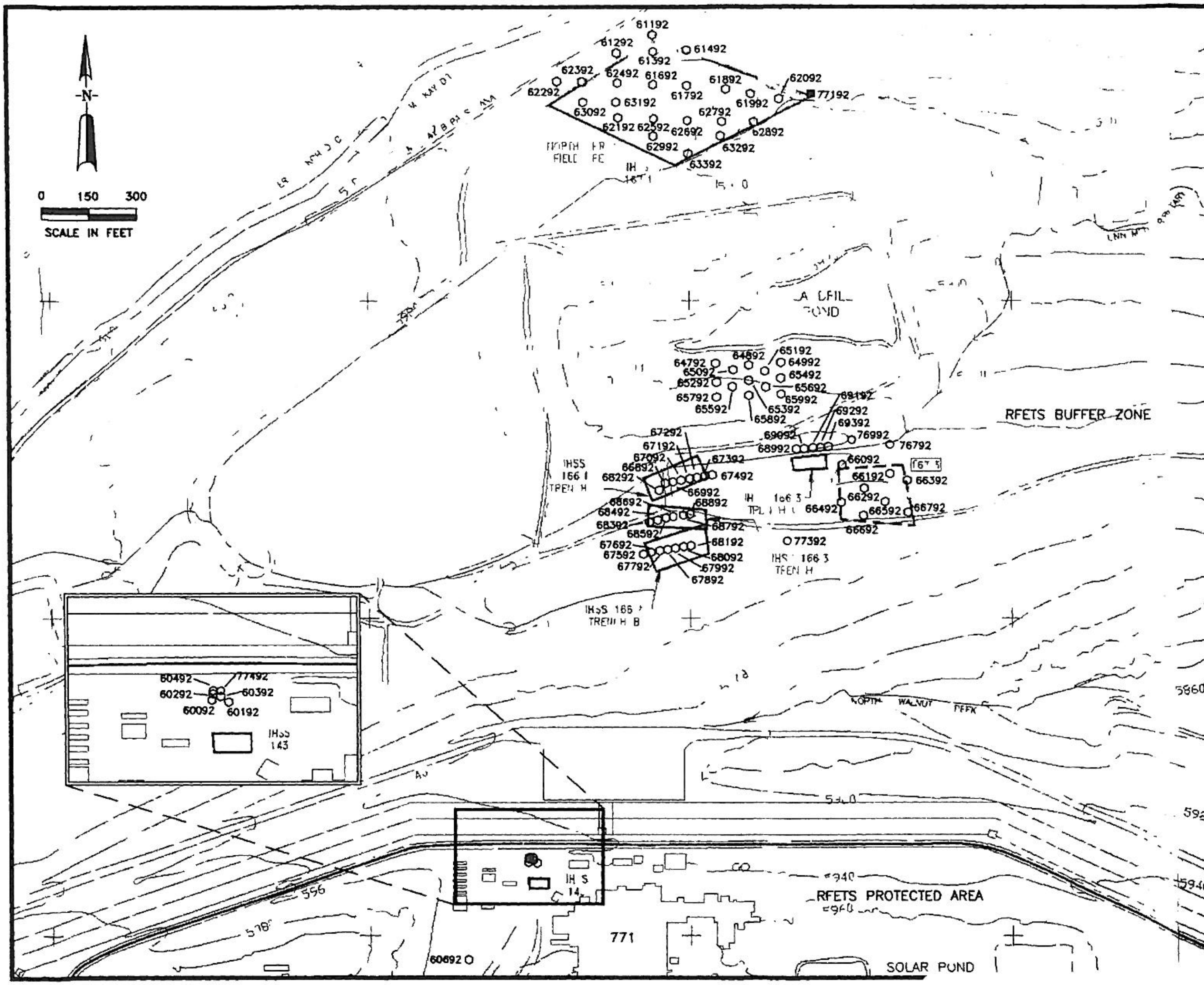

EXPLANATION

IHSS BOUNDARIES

167 3 — HISTORICAL IHSS BOUNDARY DOE 1987

60692 — SOIL BORING

77192 — MONITORING WELL (COLLUVIAL)

77392 — MONITORING WELL (ALLUVIAL)

TOPOGRAPHIC CONTOUR INTERVALS 20 FEET
DATUM IS MEAN SEA LEVEL

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SOIL BORING AND MONITORING WELL LOCATIONS
(IHSSs 143 166 1-3 167 1 AND 167 3)

FIGURE 3 5-1

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/8/9 OU6R274 1=300

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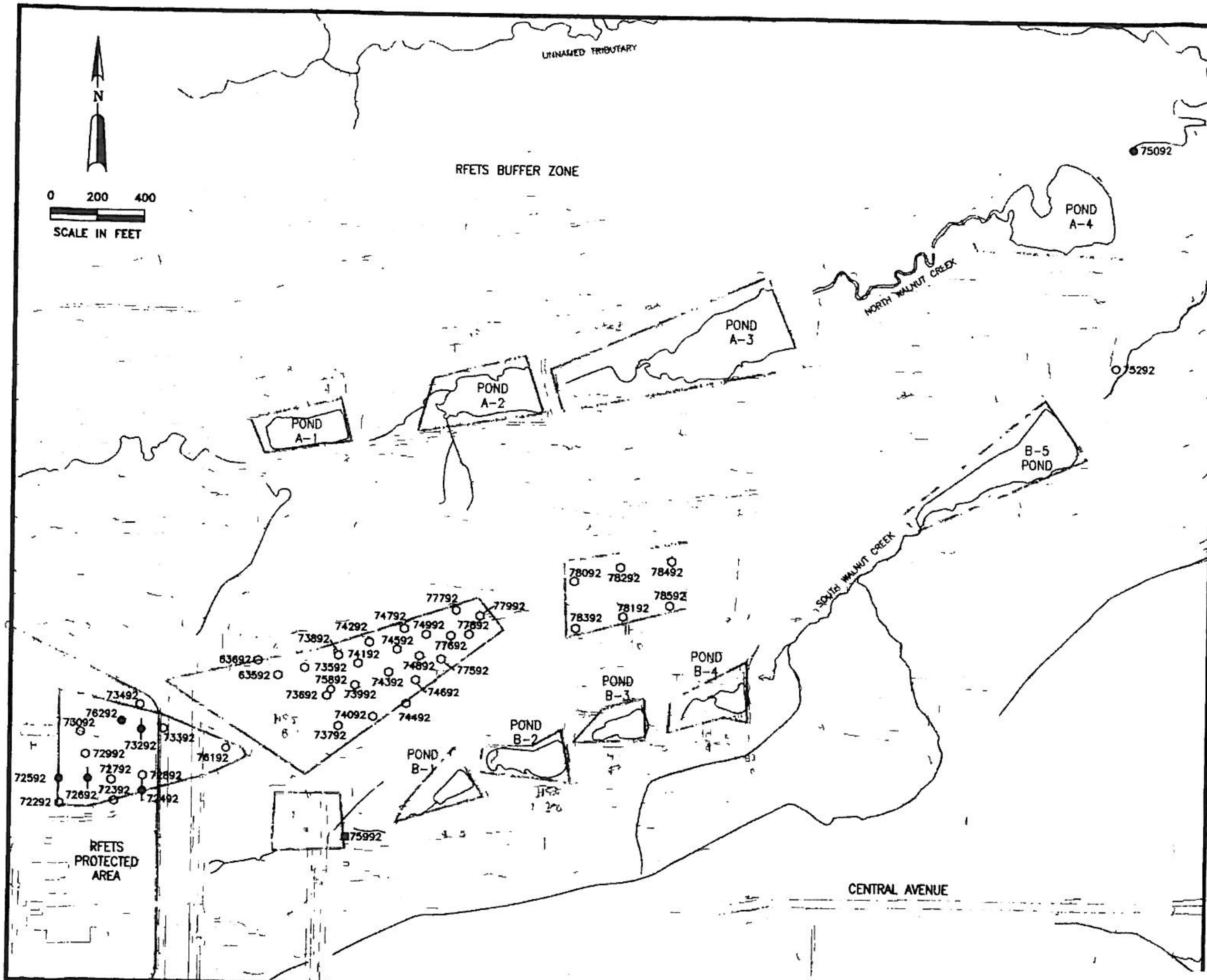

EXPLANATION

IHSS BOUNDARIES

72992 SOIL BORING

72592 SOIL CORE

75992 MONITORING WELL (COLLUVIAL)

75292 MONITORING WELL (ALLUVIAL)

75092 MONITORING WELL (BEDROCK)

TOPOGRAPHIC CONTOUR INTERVALS 20 FEET
DATUM IS MEAN SEA LEVEL

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SOIL BORING SOIL CORE AND MONITORING WELL LOCATIONS (IHSSs 141 142 4 142 9 156 2 165 AND 216 1)

FIGURE 3 5-2 APRIL 1995

3 OU6R275 1-400

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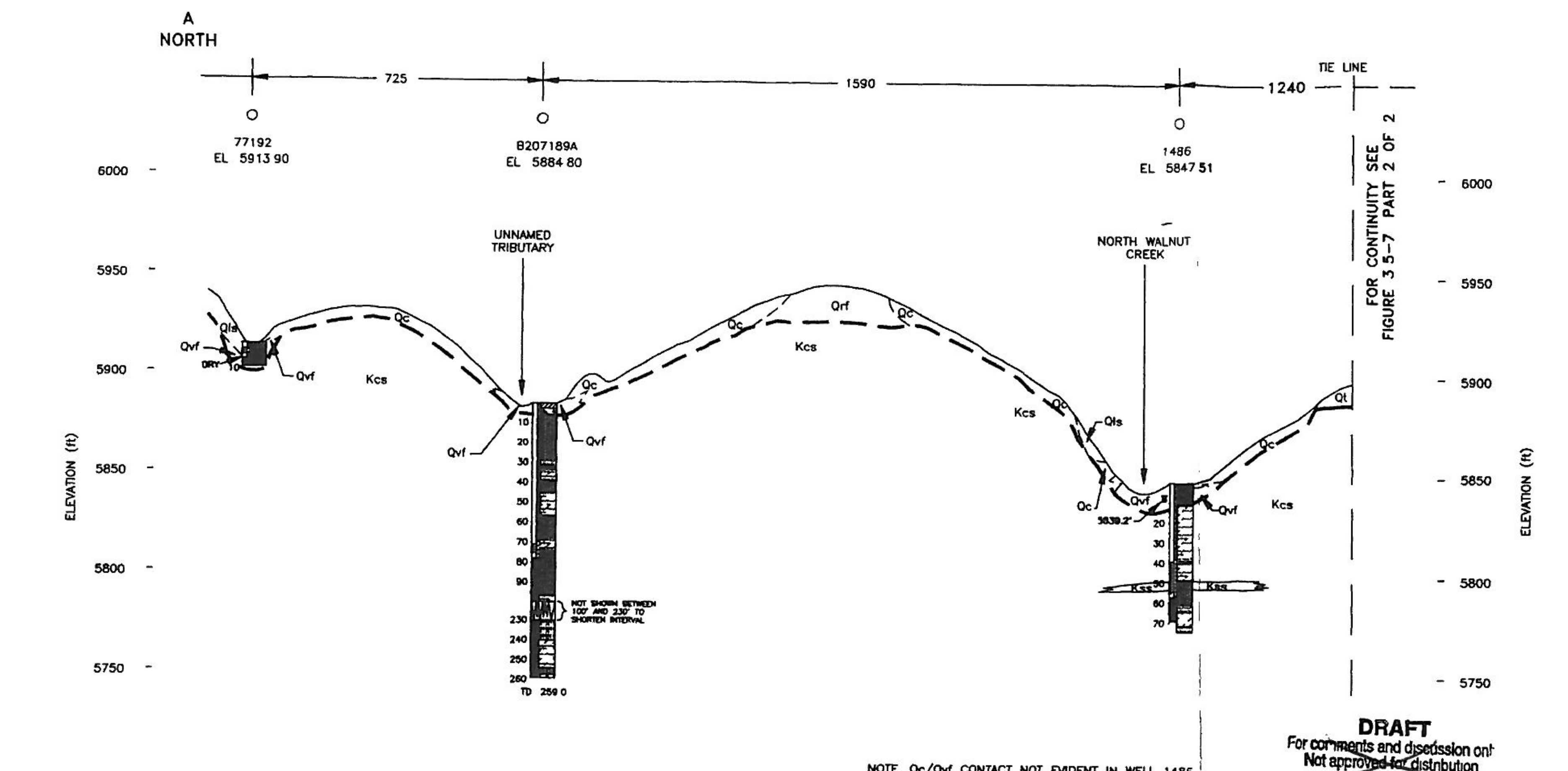

NOTE Qc/Qvf CONTACT NOT EVIDENT IN WELL 1486

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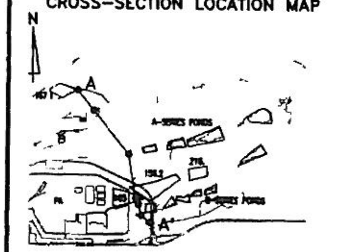
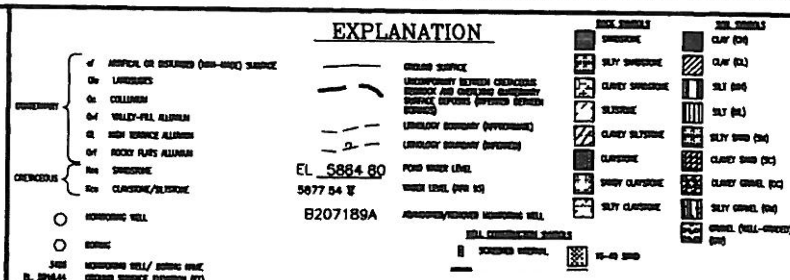
CROSS-SECTION LOCATION MAP



EXPLANATION



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NORTH – SOUTH
GEOLOGIC CROSS SECTION A–A'
TRAVERSE ACROSS THE DRAINAGES
OF NORTH WALNUT AND SOUTH WALNUT
CREEKS AND THE UNNAMED TRIBUTARY

PART 1 OF 2

FIGURE 3 5-7

JUNE 1995

OU6R031 1-1

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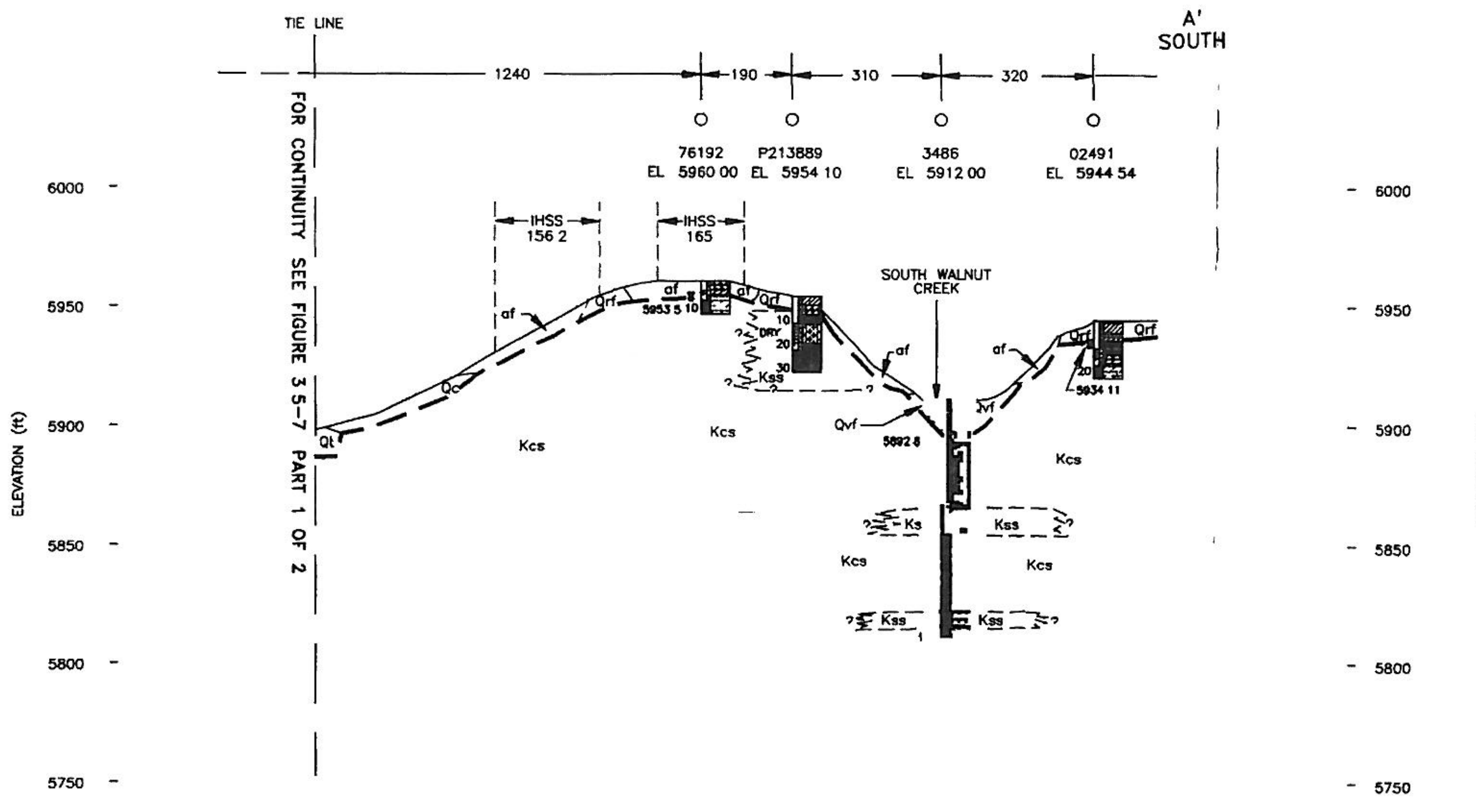

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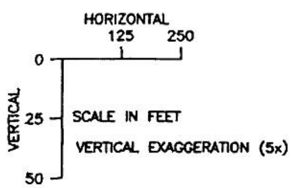
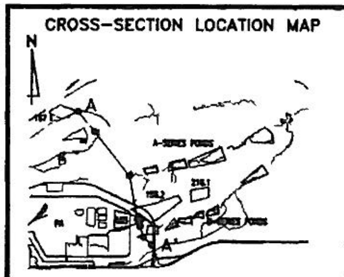
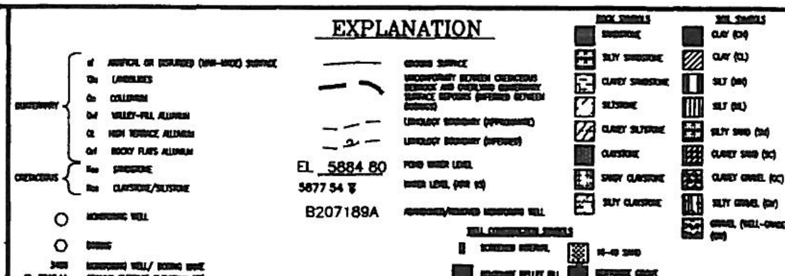




EXPLANATION



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NORTH – SOUTH
GEOLOGIC CROSS SECTION A–A
TRAVERSE ACROSS THE DRAINAGES OF
NORTH WALNUT AND SOUTH WALNUT
CREEKS AND THE UNNAMED TRIBUTARY
PART 2 OF 2

FIGURE 3 5-7

JUNE 1995

OU6R032 1=1

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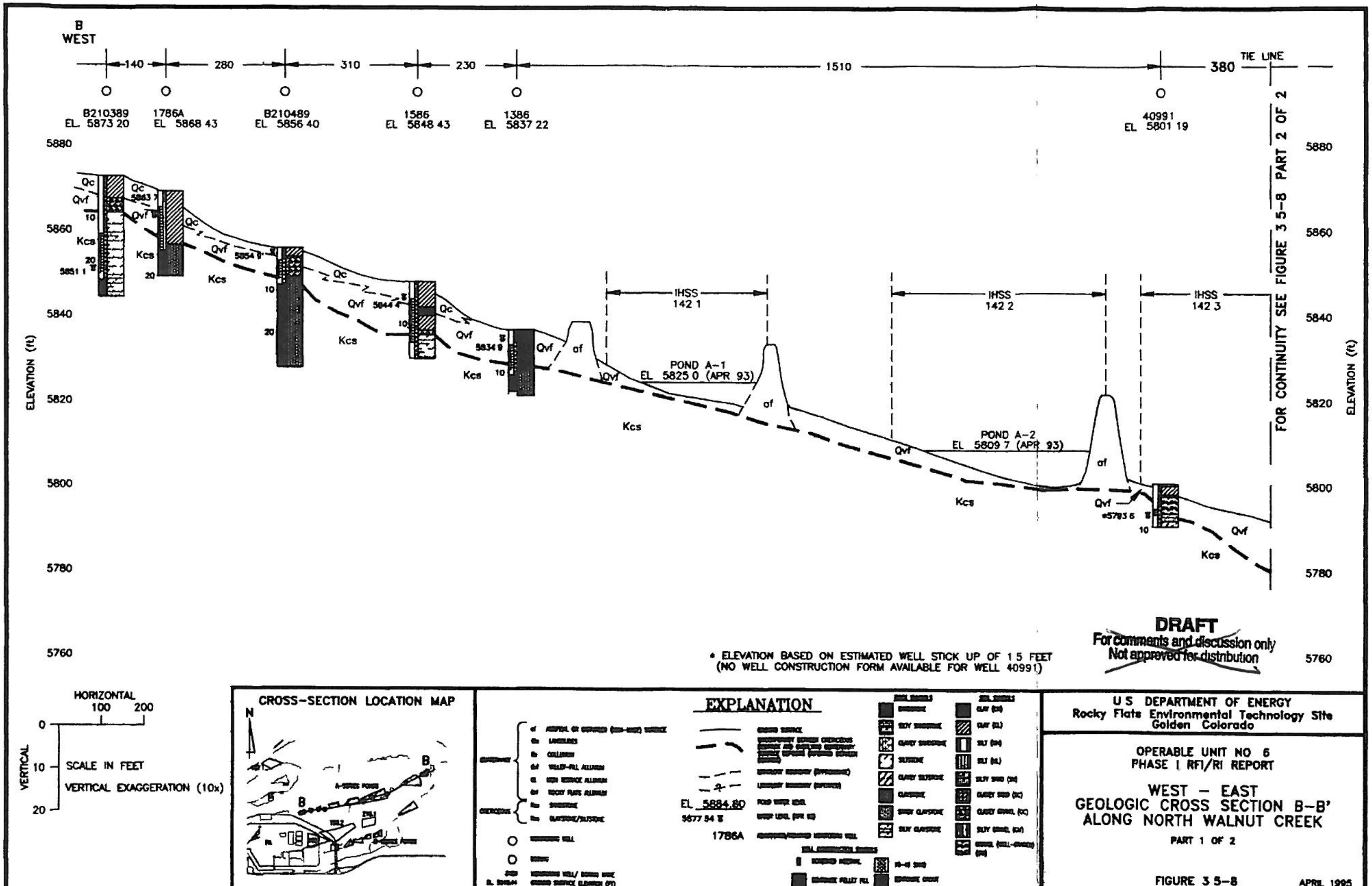

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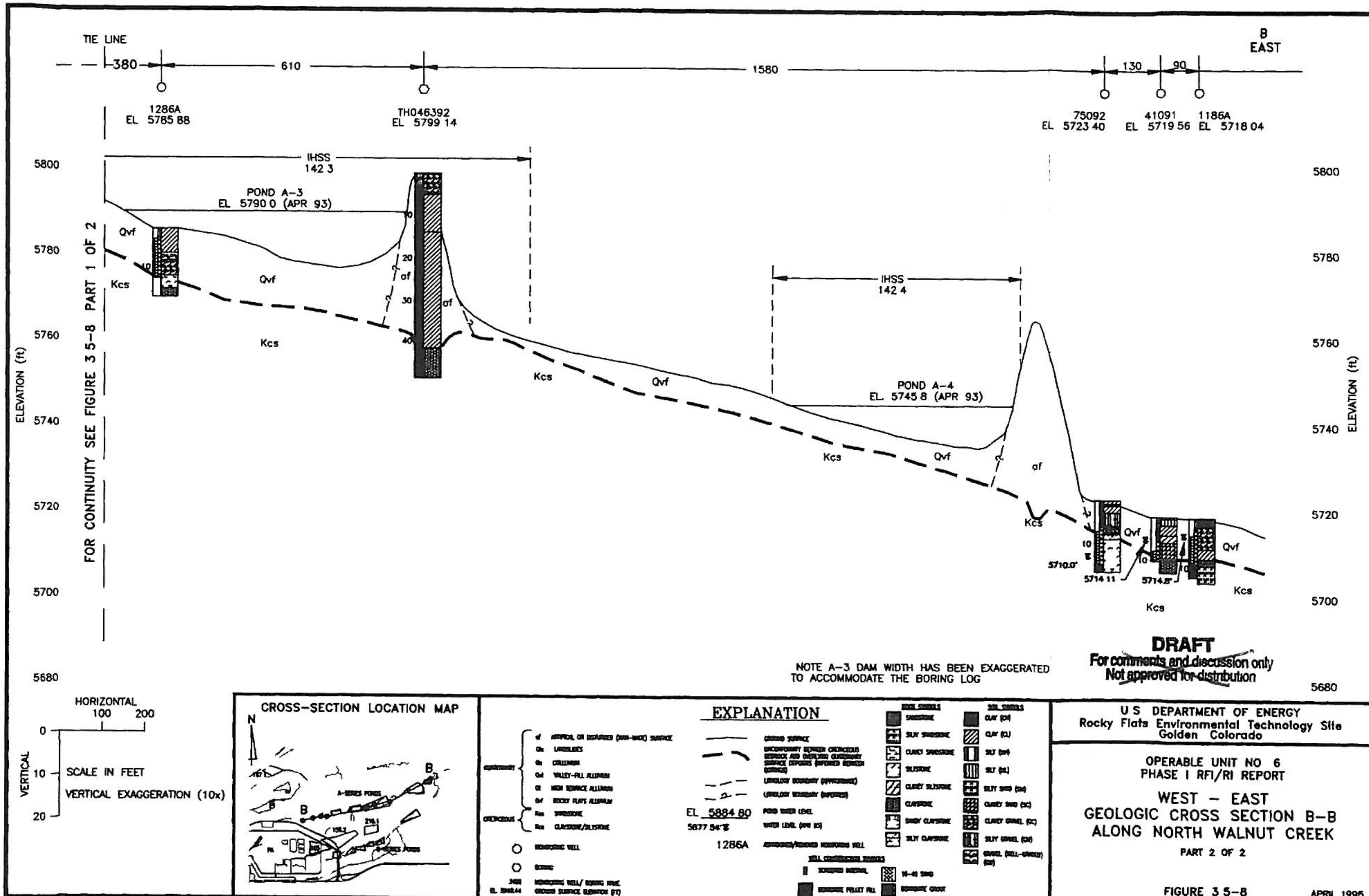

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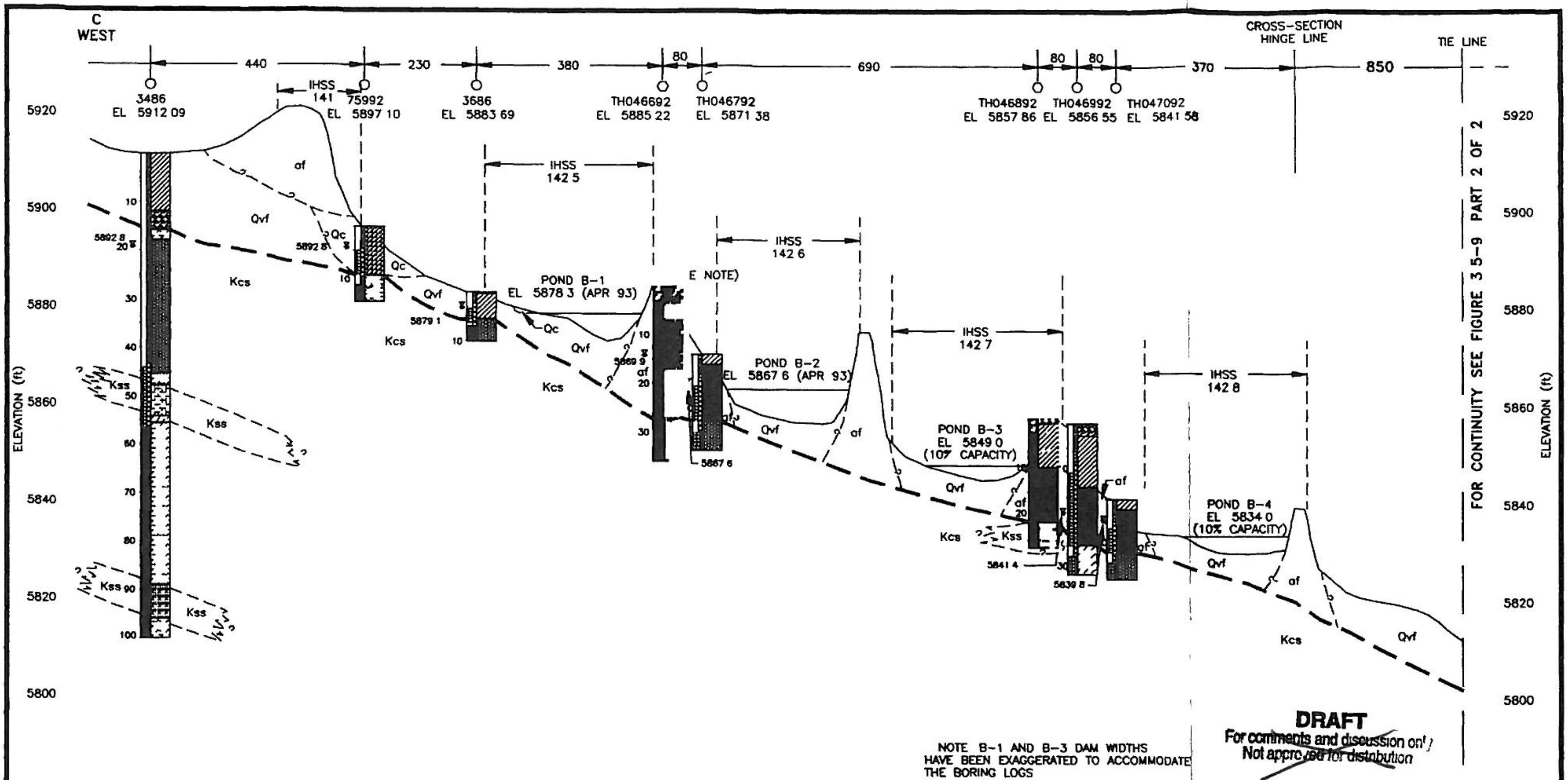

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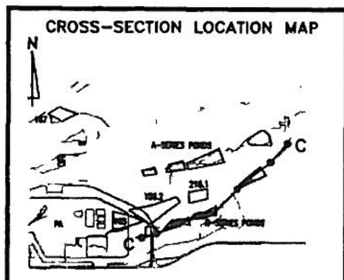

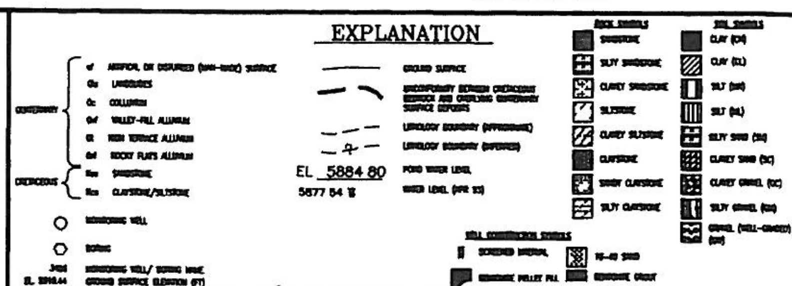

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WEST - EAST
GEOLOGIC CROSS SECTION C-C
ALONG SOUTH WALNUT CREEK

PART 1 OF 2

FIGURE 3 5-9

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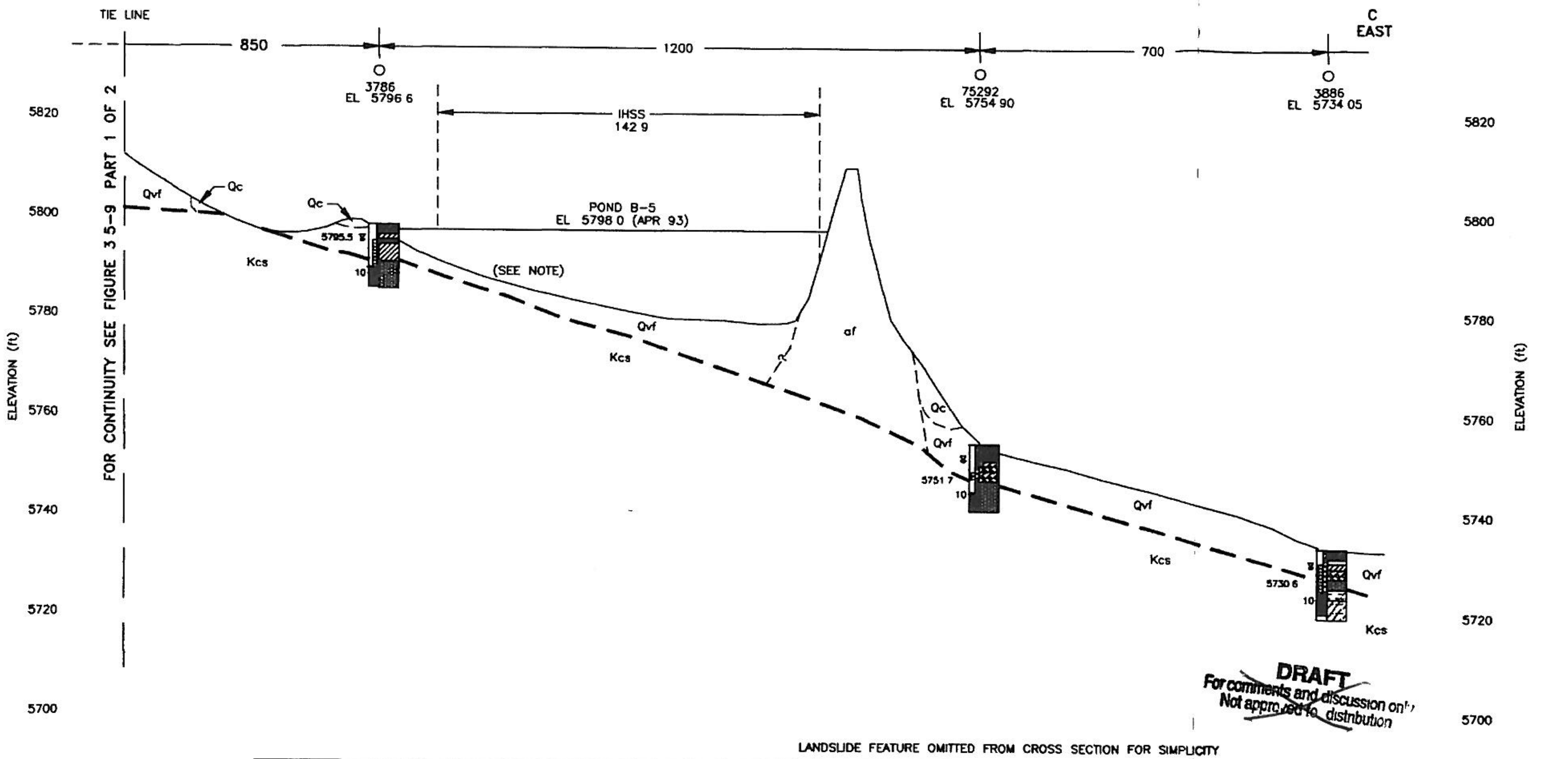

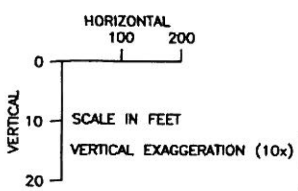

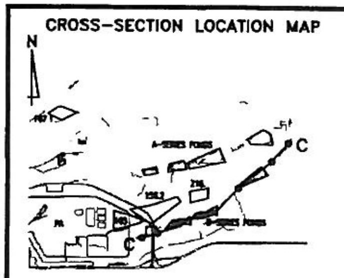

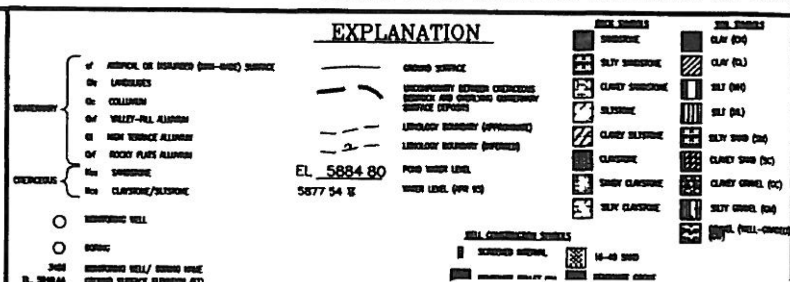

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WEST – EAST
GEOLOGIC CROSS SECTION C-C
ALONG SOUTH WALNUT CREEK

PART 2 OF 2

FIGURE 3 5-9 APRIL 1995

OU6R085 1=1

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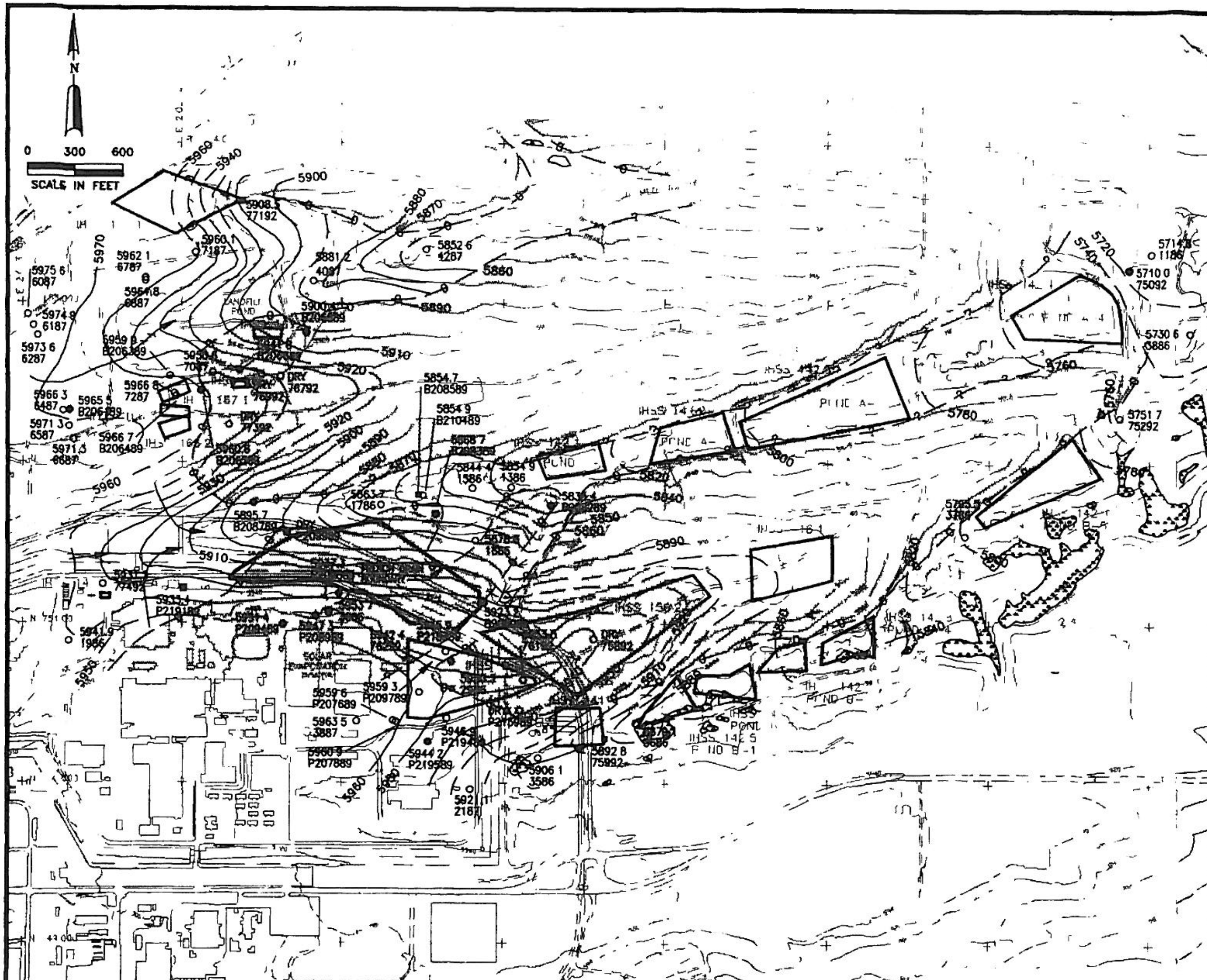

EXPLANATION

- ● UHSU BEDROCK WELL
- ○ ALLUVIAL WELL
- ■ COLLUVIAL WELL
- FRENCH DRAIN BOUNDARY
- UNSATURATED SURFACE (UNCONSOLIDATED) MATERIALS ZONE
- SEEPS — Vegetated Area Associated With Groundwater Seepage (Vegetation consists of cattails, bulbs, rushes and some woody bushes). Seepage Face Along Uphill Boundary of Vegetated Area
- 5800 — LINE OF EQUAL GROUNDWATER ELEVATION IN FEET MEAN SEA LEVEL (MSL) CONTOUR INTERVAL (CI)= 10 CI = 20 AT POND DASHED WHERE APPROXIMATE
- APPROXIMATE LINE OF ZERO SATURATED THICKNESS OF SURFACE MATERIALS (? WHERE EXTRAPOLATED)
- SURFACE ELEVATION (CI = 20 FT)
- GROUNDWATER FLOW PATHLINE
- IHSS LOCATION WITH IHSS NUMBER INDICATED

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POND WATER ELEVATIONS

POND ID	ELEVATION
A-1	5825 0
A-2	5809 7
A-3	5790 0
A-4	5745 8
B-1	5878 3
B-2	5867 6
B-3	NO DATA
B-4	NO DATA
B-5	5798 1
LANDFILL	5919 9

(FEET-MSL) (MEASURED APRIL 2 1993)

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UPPER HYDROSTRATIGRAPHIC UNIT POTENTIOMETRIC SURFACE MAP (APRIL, 1993)

FIGURE 3 6-1

APRIL 1995

3/29 95

OU6R047 1=600

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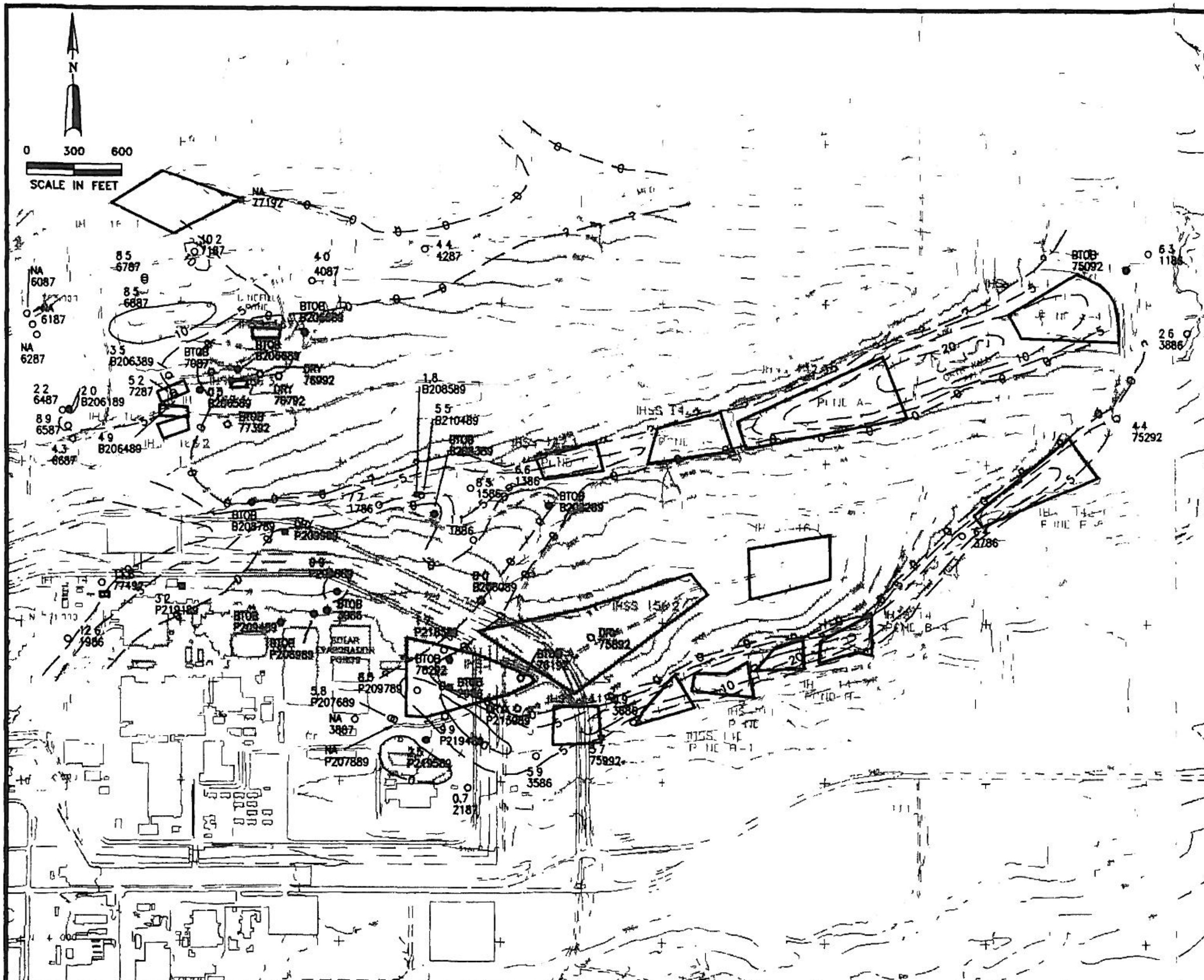

EXPLANATION

- ● USHU BEDROCK WELL
- ○ ALLUVIAL WELL
- ▪ COLLUVIAL WELL
- UNSATURATED SURFACE (UNCONSOLIDATED) MATERIALS ZONE
- — 5 — LINE OF EQUAL SATURATED THICKNESS DASHED WHERE INFERRED

  CONTOUR INTERVAL (CI) = 5

  NOTE POND WATER ELEVATION DATA (FIGURE 3 6-1) USED FOR CONTROL IN VICINITY OF PONDS
- LINE OF ZERO SATURATED THICKNESS OF SURFACE MATERIALS (? WHERE EXTRAPOLATED)
- IH 11 1 — IHSS LOCATION WITH IHSS NUMBER INDICATED
- SURFACE ELEVATION IN FEET ABOVE MEAN SEA LEVEL (CI = 20 FT)
- 1 8 B208589 — SATURATED THICKNESS (IN FEET) AND WELL IDENTIFICATION NUMBER
- BTOB — GROUNDWATER SURFACE BELOW TOP OF BEDROCK
- NA — BEDROCK ELEVATION NOT KNOWN OR BEDROCK NOT ENCOUNTERED SATURATED THICKNESS UNKNOWN

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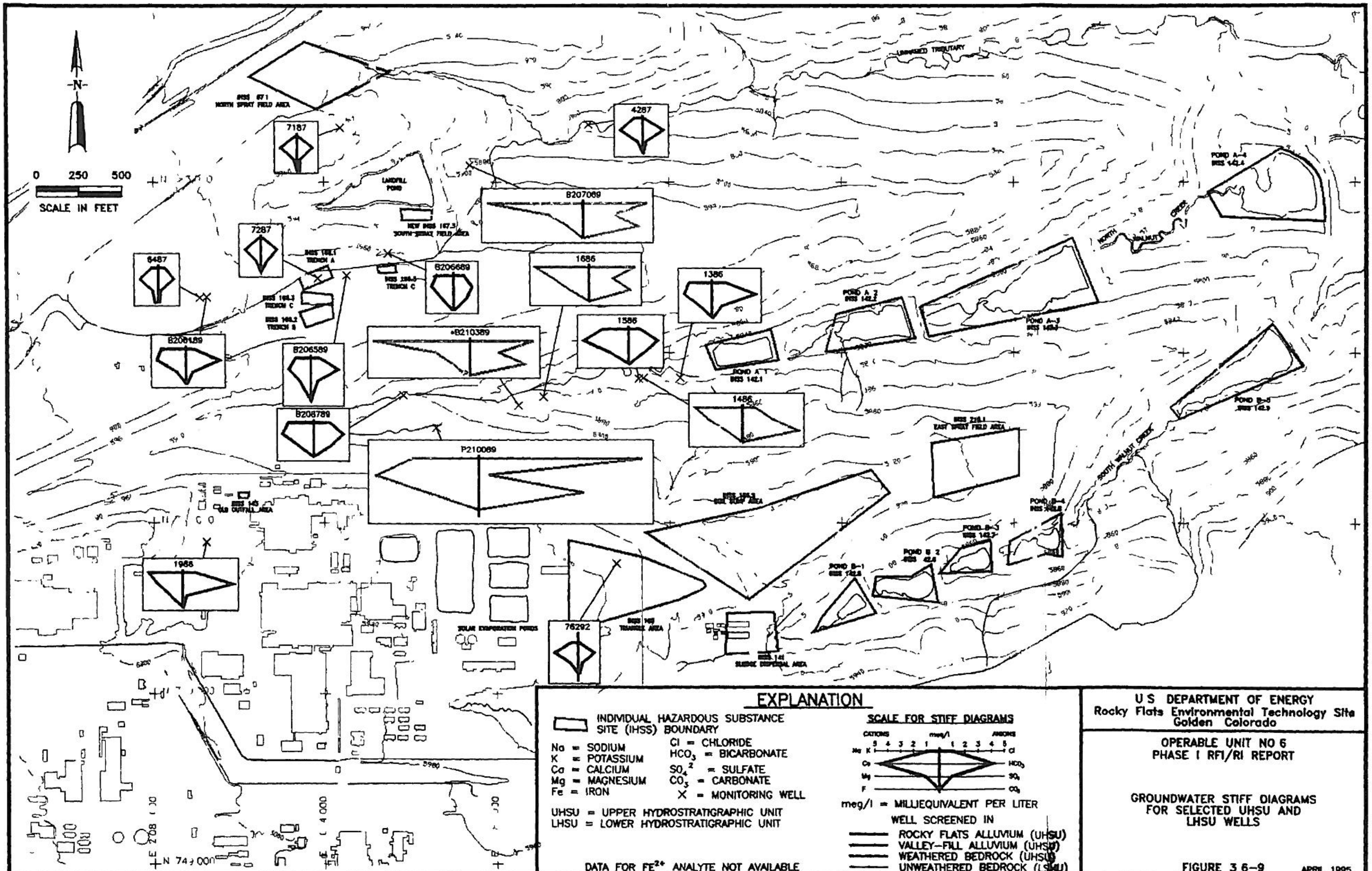
UPPER HYDROSTRATIGRAPHIC UNIT
SATURATED THICKNESS OF
SURFACE MATERIALS MAP (APRIL, 1993)

FIGURE 3 6-2

APRIL 1995

OU6R102 1=600



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GROUNDWATER STIFF DIAGRAMS FOR SELECTED UHSU AND LHSU WELLS

FIGURE 3 6-9

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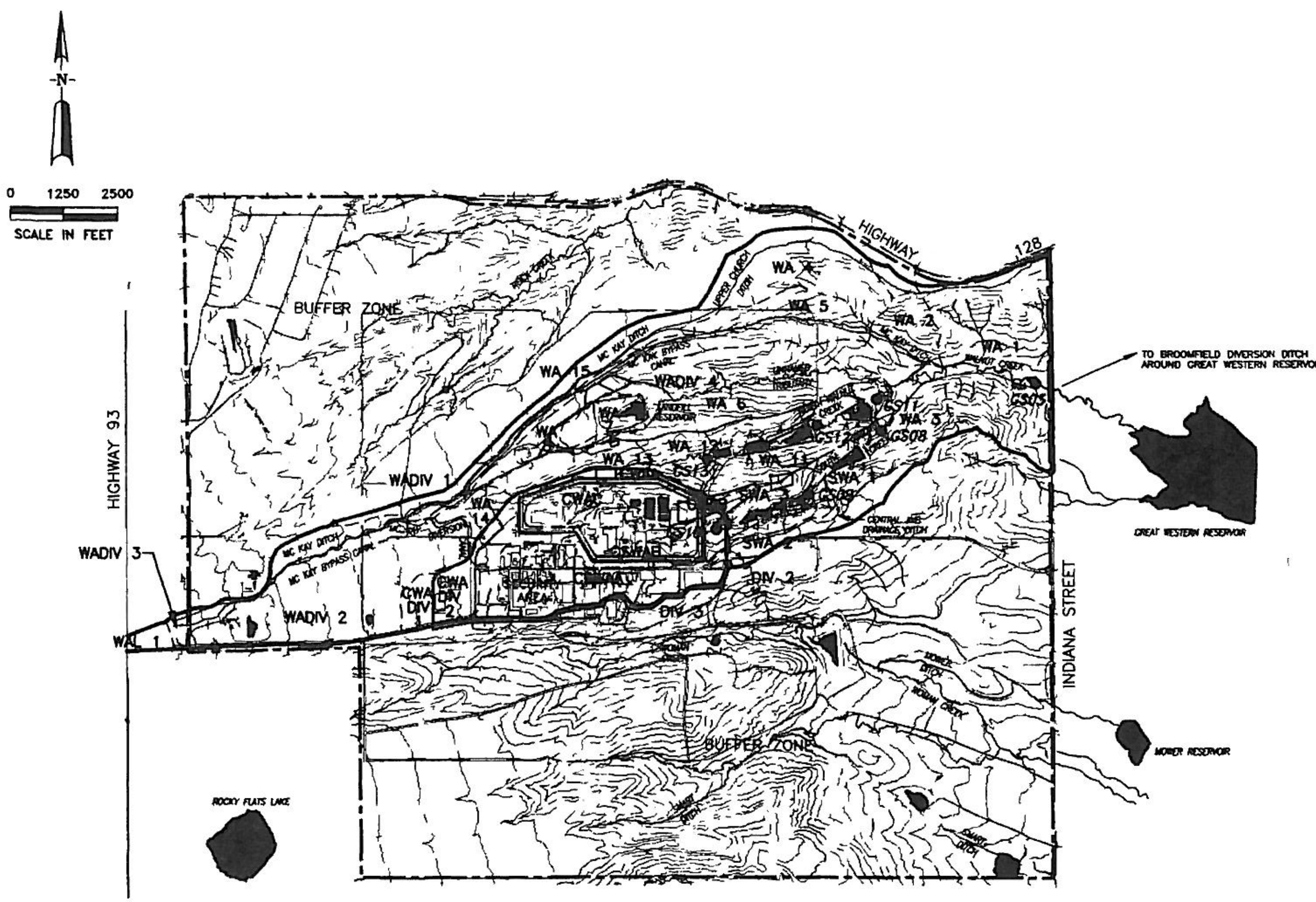
OU6RI01 1=500



FROM RFP DRAINAGE AND FLOOD CONTROL MASTER PLAN (EG&G 1992c)

EXPLANATION

- WALNUT CREEK DRAINAGE BASIN BOUNDARY (UPSTREAM OF INDIANA STREET)
- RFETS BOUNDARY
- SECURITY AREA BOUNDARY
- SUB-BASIN BOUNDARY
- POND OR RESERVOIR
- WA 1 — DRAINAGE SUB-BASIN IDENTIFICATION
- GS03 — GAUGING STATION
- INDIVIDUAL HAZARDOUS SUBSTANCE SITES

CONTOUR INTERVAL = 20

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ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE DRAINAGE BASIN MAP

FIGURE 3 7-1 JUNE 1995

OU6R1103 1=2500

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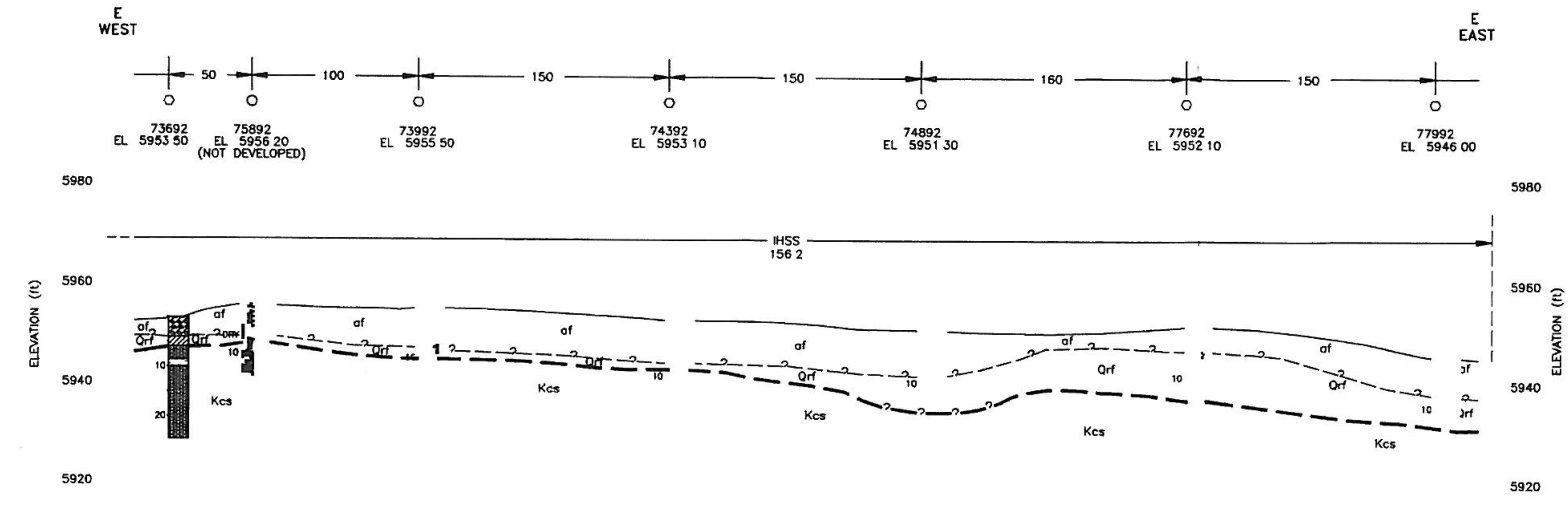
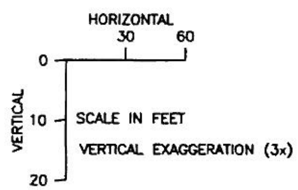
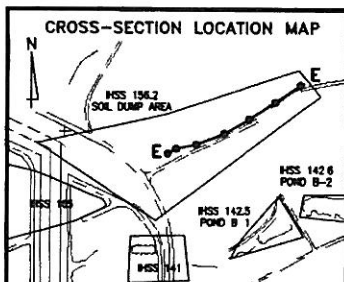
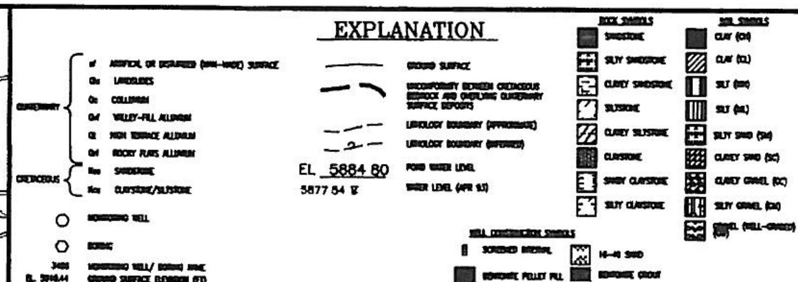


af/Qrf CONTACT PLACED AT TOP OF CALICHE ZONE ENCOUNTERED IN BORINGS







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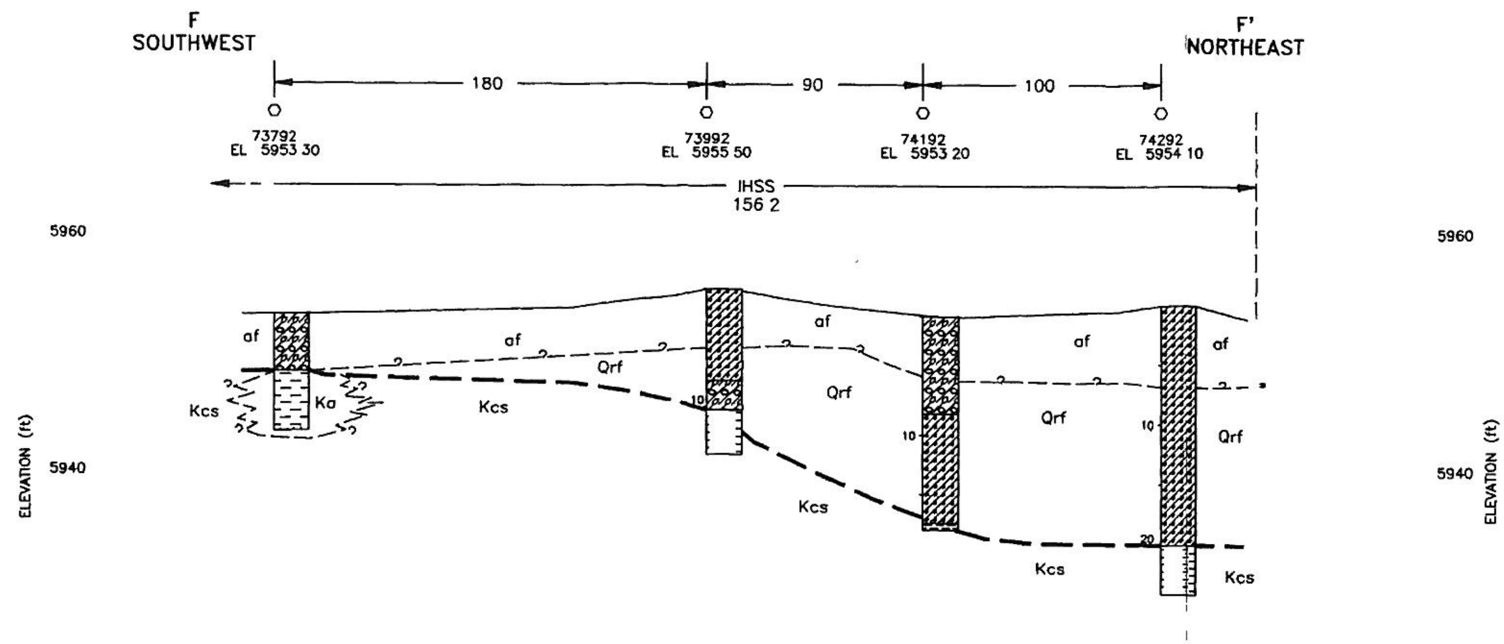
WEST – EAST
GEOLOGIC CROSS SECTION E–E
THROUGH IHSS 156 2

FIGURE 3 9–3

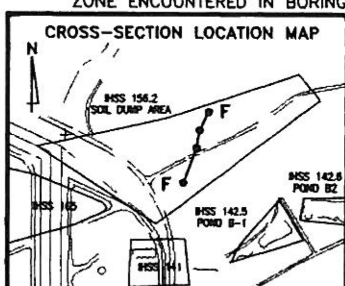
APRIL 1995

OU6R086 1-1



* af/Qrf CONTACT PLACED AT TOP OF CALICHE ZONE ENCOUNTERED IN BORINGS

HORIZONTAL
0 25 50
VERTICAL
0 5 10
SCALE IN FEET
VERTICAL EXAGGERATION (5x)



EXPLANATION

EL 5884 80
5877 54

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SOUTHWEST – NORTHEAST
GEOLOGIC CROSS SECTION F–F'
THROUGH IHSS 156 2

FIGURE 3 9–4

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OU6R087 1=1

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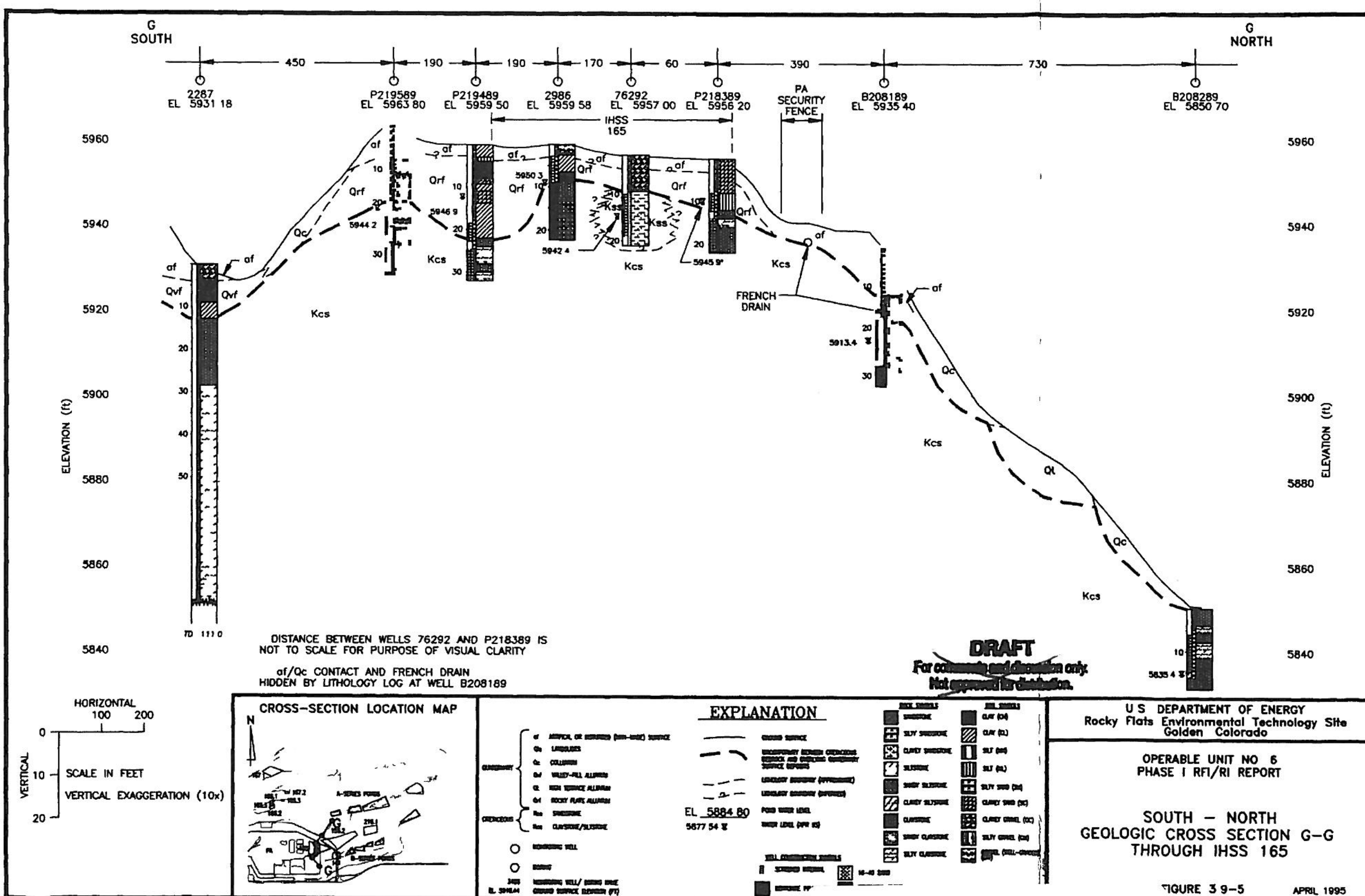

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SOUTH – NORTH
GEOLOGIC CROSS SECTION G-G
THROUGH IHSS 165

FIGURE 3 9-5 APRIL 1995

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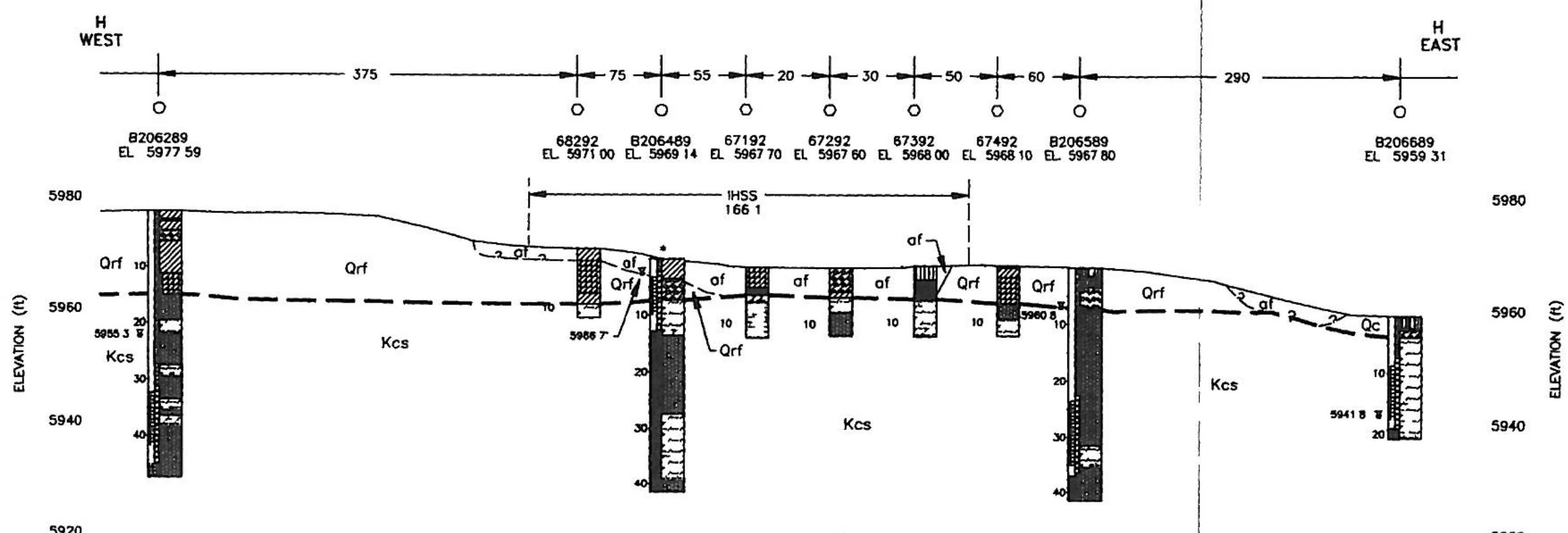

DISTANCES BETWEEN BORINGS B206489 67192 67292 67392 67492 AND B206589 ARE NOT TO SCALE FOR PURPOSE OF CLARITY

TRENCH A BOUNDARY HIDDEN BY LITHOLOGY LOG AT WELL B206489

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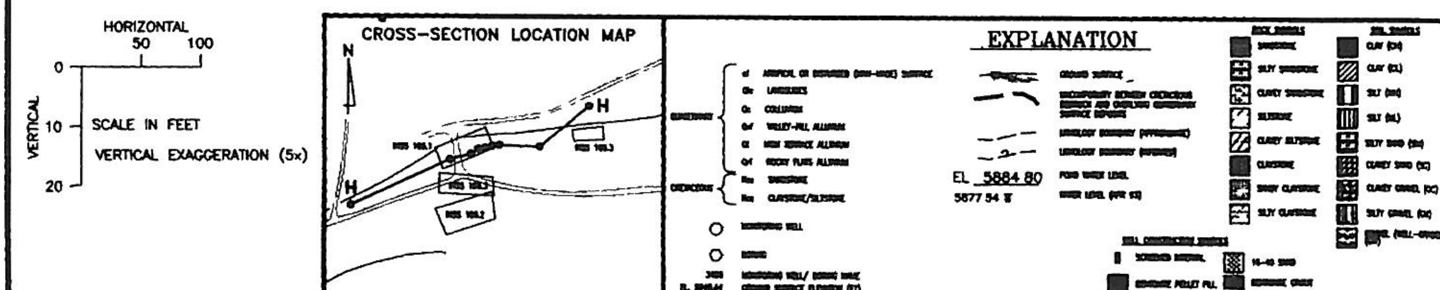

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WEST–EAST
GEOLOGIC CROSS SECTION H–H
THROUGH IHSS 166 1

FIGURE 3 9–6 APRIL 1995

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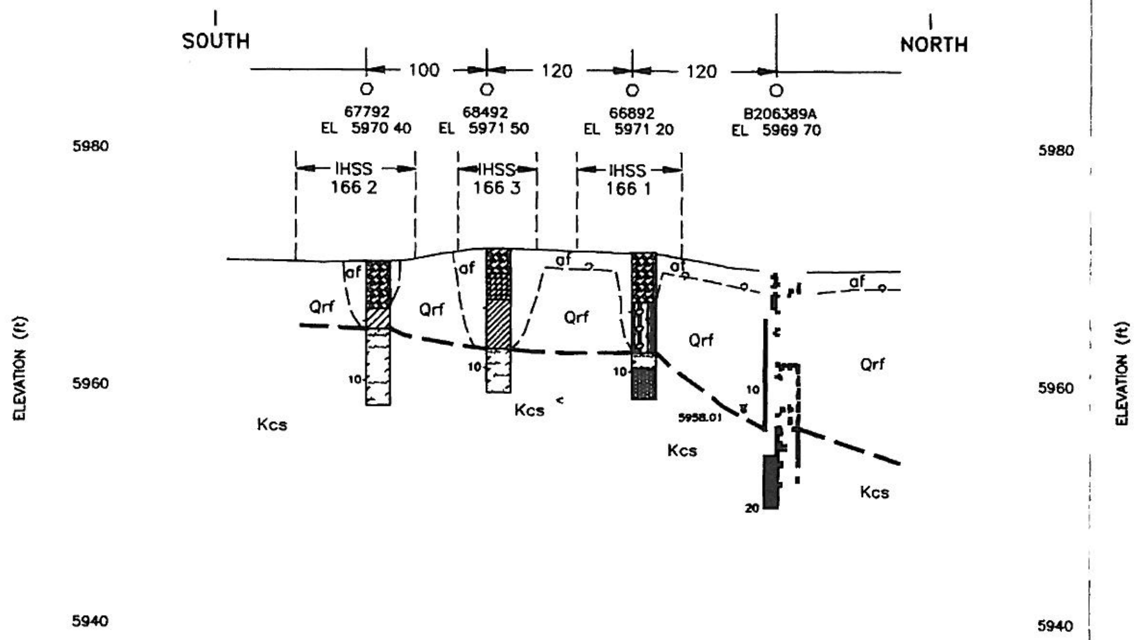

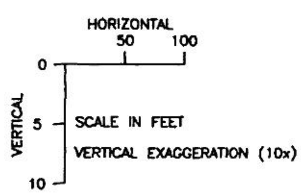

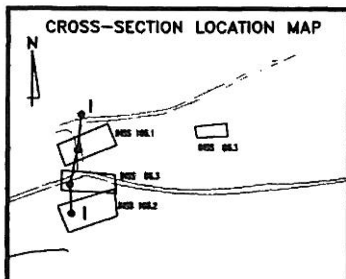

EXPLANATION

EL 5884 80

5877 54

B206389A

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SOUTH-NORTH
GEOLOGIC CROSS SECTION I-I
THROUGH IHSSs 166 1 - 166 3

FIGURE 3 9-7

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OU6R089 1=1

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Soils in the OU6 Study Area

- DENVER CLAY LOAM 2 to 5 percent slopes
- DENVER-KUTCH-MIDWAY CLAY LOAMS 9 to 25 percent slopes
- ENGLEWOOD CLAY LOAM 0 to 2 percent slopes
- ENGLEWOOD CLAY LOAM 2 to 5 percent slopes
- FLATIRONS VERY COBBLY SANDY LOAM 0 to 3 percent slopes
- HAVERSON LOAM 0 to 3 percent slopes
- LEYDEN-PRIMEN-STANDLEY COBBLY CLAY LOAMS 15 to 50 percent slopes
- NEDERLAND VERY COBBLY SANDY LOAM 15 to 50 percent slopes
- VALMONT CLAY LOAM 0 to 3 percent slopes

Other soil types shown

- DENVER CLAY LOAM 5 to 9 percent slopes
- DENVER-KUTCH CLAY LOAMS 5 to 9 percent slopes
- PITS GRAVEL
- STANDLEY-NUNN GRAVELLY CLAY LOAMS 0 to 5 percent slopes

Digital ARC/Info coverage provided by EG&G
RFPSOIL coverage digitized from Digital Line
Graph(DLG) data from Soil Conservation Service(SCS)

EXPLANATION

- 20 Topographic Contours
- Paved roads
- Dirt roads
- OU6 Study Area
- Individual Hazardous Substance Sites (IHSSs)
- Ponds Lakes and Streams
- Buildings or other structures

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N W E S

1" = 900

IHSS LOCATIONS SHOWN ARE BASED ON REVISED INTERPRETATIONS IN HRR (DOE 1992b)

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SURFACE SOIL MAP

FIGURE 3 4-1

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EXPLANATION

Ka – CRETACEOUS ARAPAHOE FORMATION No. 1 SANDSTONE OUTCROP

MONITORING WELL/BOREHOLE THAT PENETRATED CRETACEOUS ARAPAHOE No.1 SANDSTONE

Kl (SS)– CRETACEOUS LARAMIE FORMATION SANDSTONE OUTCROP

MONITORING WELL/BOREHOLE THAT PENETRATED CRETACEOUS LARAMIE SANDSTONE

K (CLST/SLTST) – CRETACEOUS CLAYSTONE/SILTSTONE OUTCROP

MONITORING WELL/BOREHOLE THAT PENETRATED CRETACEOUS SILTSTONE/CLAYSTONE

BUILDING/STRUCTURE OUTLINE

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) BOUNDARY AND IHSS BOUNDARY NUMBER AND IDENTIFICATION

BEDROCK CONTOUR AND ELEVATION

INFERRED BEDROCK CONTOUR AND ELEVATION

74792 = SITE IDENTIFICATION

5943.3 = BEDROCK ELEVATION

PAVED ROAD

SURFACE WATER DRAINAGES AND PONDS

OU6 BOUNDARY

LOCATION OF GEOLOGIC CROSS-SECTION WITH WELL/BORING NUMBER

CONTOUR INTERVAL = 20 FEET, EXCEPT FOR OU2 AREA, WHERE CONTOUR INTERVAL = 10 FEET
DATUM IS MEAN SEA LEVEL

NOTE:
OU2 AREA BEDROCK DATA AND INTERPRETATION FROM DOE 1993e

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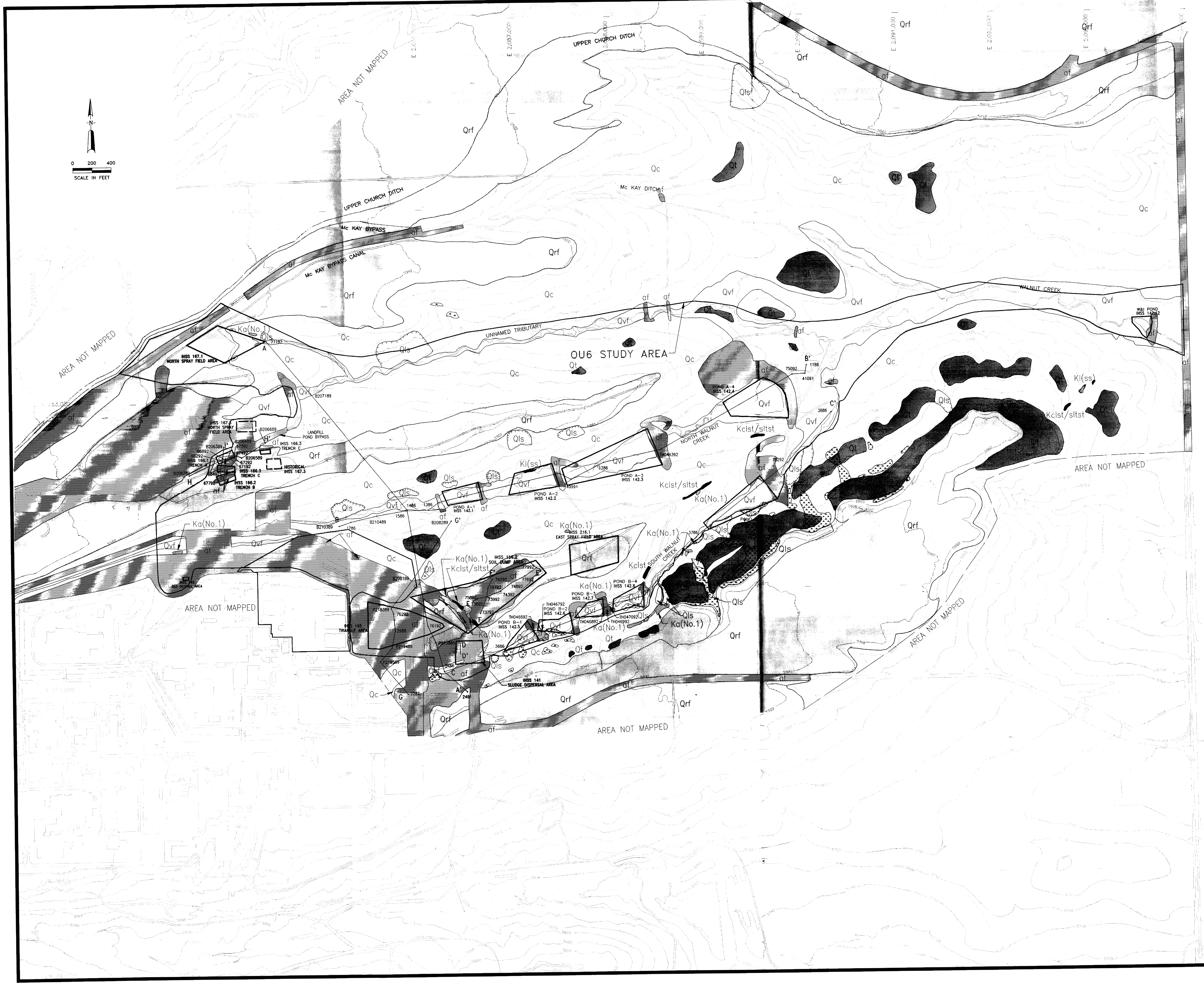
BEDROCK SURFACE
MAP OF OU6 STUDY AREA

PLATE 3.5–3 APRIL 1995

OU6RI069 1=400



EXPLANATION

QUATERNARY
- af – ARTIFICIAL FILL OR DISTURBED (MAN-MADE) SURFACE
- Qls – LANDSLIDES
- Qc – COLLUVIUM
- Qvf – VALLEY-FILL ALLUVIUM
- Qt – HIGH TERRACE ALLUVIUM
- Qrf – ROCKY FLATS ALLUVIUM

CRETACEOUS
- Ka(No.1) – ARAPAHOE No.1 SANDSTONE OUTCROP
- Kl(ss) – LARAMIE FORMATION SANDSTONE OUTCROP
- Kclst/sltst – CLAYSTONE/SILTSTONE OUTCROP

BUILDING/STRUCTURE OUTLINE

IHSS 167.1 NORTH SPRAY FIELD AREA
INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) BOUNDARY
IHSS BOUNDARY NUMBER AND TITLE

IHSS 167.1 NORTH SPRAY FIELD AREA
HISTORICAL INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) BOUNDARY
IHSS BOUNDARY NUMBER AND TITLE

F' 74192 74292 73992 73792 F
LOCATION OF GEOLOGIC CROSS SECTION WITH WELL/BORING NUMBER

PAVED ROAD

SURFACE WATER DRAINAGES

OU6 STUDY AREA

SEEPS

Vegetated Area Associated With Groundwater Seepage (Vegetation consists of cattails, baltic rushes, and some woody bushes). Seepage Face Along Uphill Boundary of Vegetated Area.

CONTOUR INTERVALS 20 FEET
DATUM IS MEAN SEA LEVEL

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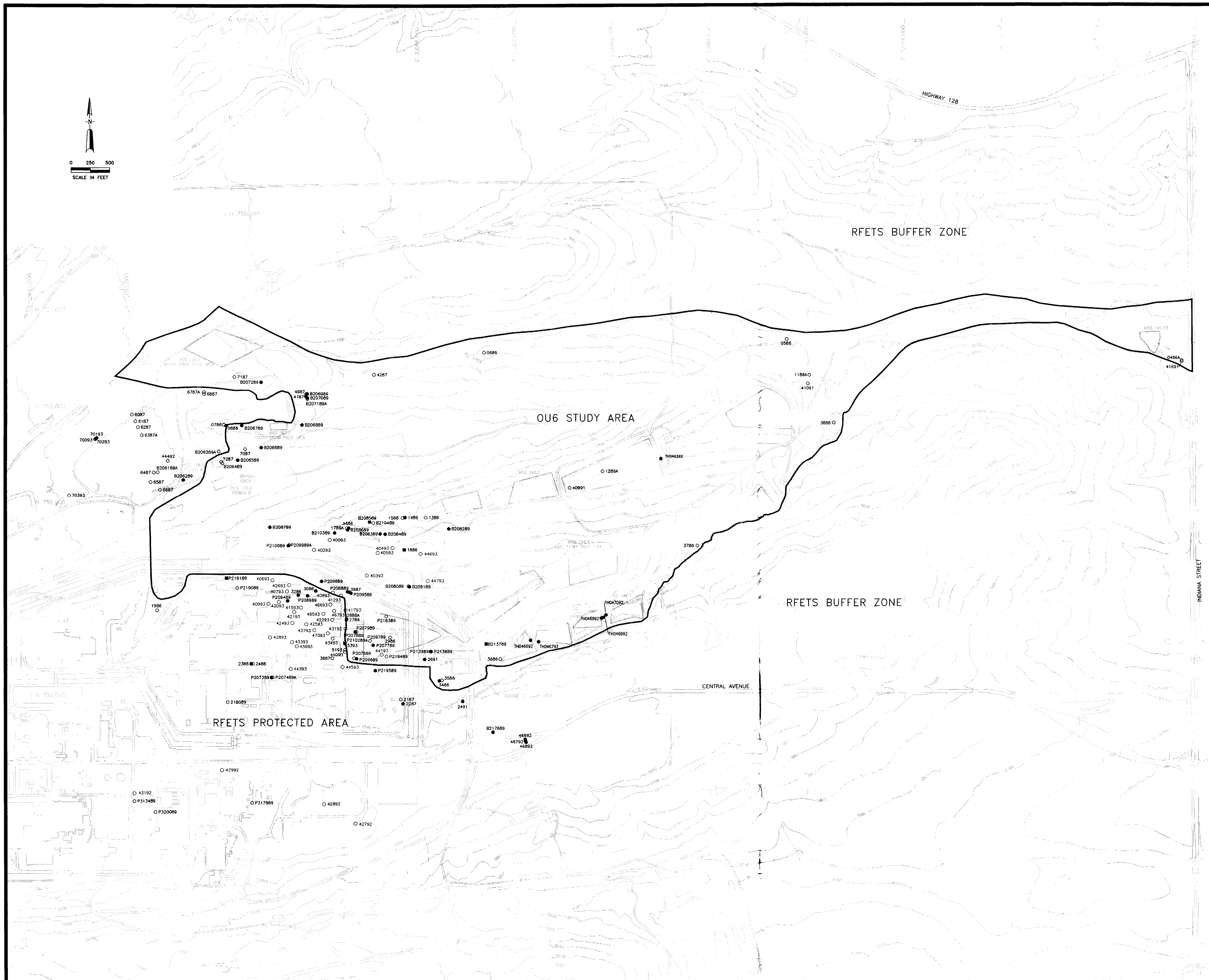
SURFACE GEOLOGIC
MAP OF OU6 STUDY AREA

PLATE 3.5-2

APRIL 1995

OU6RI036 1=400



EXPLANATION

IHSS 167.1 NORTH SPRAY FIELD AREA — INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) BOUNDARY WITH IHSS BOUNDARY NUMBER AND IDENTIFICATION

OU6 STUDY AREA

219189 — COLLUVIAL MONITORING WELL

6087 — ALLUVIAL MONITORING WELL

0686 — BEDROCK MONITORING WELL

42892 — BOREHOLE LOCATION

1286A — ABANDONED MONITORING WELL

TOPOGRAPHIC CONTOUR INTERVALS 20 FEET
DATUM IS MEAN SEA LEVEL

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BOREHOLE AND MONITORING WELL
LOCATIONS OF OU6 HISTORICAL
AND OTHER INVESTIGATIONS
(OU2, OU4, OU7)

PLATE 3.5-1 APRIL 1995

OU6RI276 1=500